A. I. Levorsen

Volume 21 MARCH, 1937 Number 3

BULLETIN
of the
American Association *of* Petroleum Geologists

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BULLETIN

of the

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

OFFICE OF PUBLICATION, 608 WRIGHT BUILDING, TULSA, OKLAHOMA

THE BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS is published by the Association on the 15th of each month. Editorial and publication office, 608 Wright Building, Tulsa, Oklahoma, Post Office Box 1852. Cable address, AAPGEOL.

THE SUBSCRIPTION PRICE to non-members of the Association is $15.00 per year (separate numbers $1.50) prepaid to addresses in the United States. For addresses outside the United States, an additional charge of $0.40 is made on each subscription to cover extra wrapping and handling.

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German agent: Max Weg, Königstrasse 3, Leipzig, Germany.

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THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, INC.

BOX 1852

TULSA, OKLAHOMA

Entered as second-class matter at the Post Office of Tulsa, Oklahoma, and at the Post Office at Menasha, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1923.

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, INC.

(Organized at Tulsa, Oklahoma, February 10, 1917, as the Southwestern Association of Petroleum Geologists. Present name adopted, February 16, 1918. Incorporated in Colorado, April 23, 1924. Domesticated in Oklahoma, February 9, 1925.)

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Volume 21 Number 3

BULLETIN
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AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

MARCH, 1937

OIL POSSIBILITIES IN ITALIAN EAST AFRICA[1]

A. BELLUIGI[2]
Addis Abeba, Italian East Africa

ABSTRACT

Although surface showings of petroleum in Abyssinia are a matter of record, the structural conditions ordinarily considered favorable and necessary for the accumulation of commercial deposits are absent. The sedimentary rocks seem to lack domes and anticlines, but folds and reservoir traps may be found where thrusting and compression have affected the younger strata in coastal zones or in depressions of the old and solid massif of Abyssomaliland. Oil reservoirs may be found along geosynclinal boundary faults.

I

Heretofore the most important articles on the possibilities of finding petroleum in Italian East Africa have been tectonic in character,[3] as the lack of oil structures in the Abyssinian Plateau is immediately noticeable. In the absence, therefore, of the necessary structural condition for the accumulation of hydrocarbons, the investigation of the conditions sufficient for the origin of petroleum seemed of second importance.

Perhaps it is not inopportune to study also this second factor, because, even though Craig's prediction be proved true, namely, that the hopes of the occurrence of oil in Abyssinia are condemned to be deluded, nevertheless there may be some possibilities of finding secondary deposits.

II

The existence of surface indications near Ankober, Harrar, Jiggiga, in Aussa, not far from the frontier between Abyssinia and British

[1] Manuscript received, December 30, 1936.

[2] Chief of the Geological and Geophysical Service of Italian East Africa.

[3] E. H. Cunningham Craig, "Is There Oil in Abyssinia?" *Petroleum Times* (London), Vol. 34 (1935), p. 271.

Somaliland, perhaps in the Lower Ogaden (valleys of Dagata, Sullul, and Tugh Fafan) can no longer be doubted, in the light of verifications and reports of authorities, for example, Professor Lacroix, and Wilfred H. Osgood, chief of the scientific expeditions organized in 1926–27 in Abyssinia by the Field Museum of Natural History of Chicago.

Further, the evidence in the Dahalak Islands has been well known for a long time, likewise in the Farasan group of islands, opposite the southern coast of the Arabic-Saudian Kingdom, northeast of the Dahalaks. A recent agreement between the Saudian Government and the Petroleum Company Ltd. of London (May 9, 1936) decrees oil exploration, not only in the Farasans, but also in the western side of the Arabic-Saudian Kingdom.

The undisputed existence of surface indications, in our opinion, is not an argument of greatest importance in this case.

Really it is enough to think that terranes of Abyssinian type, because of the great many intrusive bodies and fractures which intersect the region, would offer exceptionally good conditions for communication between the lower layers and the surface, and, if large oil accumulations really exist in some localities, prominent surface indications of hydrocarbons should appear. These have not been previously emphasized.

III

As old and massive formations prevail in Abyssinia, constituting such a compact mass that they do not permit folding movements, there are few possibilities of oil structures, at least those of definite importance.

Besides, as the lower solid massif of old rocks has protected the younger strata from folding movements, oil could not concentrate in commercial quantities.

Recently Victor Oppenheim,[4] studying the oil formations in the Gondwana rocks, excluded the existence of "active concentrations" in southern Brazil, in eastern Argentina, in Paraguay, and in Uruguay where massive tabular structures exist, which are connected with a great many intrusive bodies and fractures. All the numerous test wells drilled in the Santa Catharina system of Brazil have given negative results.

It must be admitted that neither non-folded formations nor intensely fractured formations with outcrops of basaltic masses, trav-

[4] Victor Oppenheim, "Gondwana Rocks and Geology of Petroleum of Southern Brazil," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 6 (June, 1936), p. 819.

ersed by batholiths, dikes, and sills, are the most favorable for reservoirs of natural hydrocarbons.

Yet we must add that folding and deformation may originate where thrusting, compression, and other orogenic phenomena may have affected the younger strata, which have been deposited in coastal zones or in depressions of the old and solid massif of Abyssomaliland.

It is known that near the end of Eocene time the sedimentary cover of Abyssomaliland formed flat undulations as far as the Soqotrah group similar to conditions in southern Arabia, "resonance thrusts" of folding in the Eurasiatic zones.

Also fracture tectonics, which increased during the Oligocene, can not be disconnected from compressive phenomena, and resulting effects of domes and various folds.

In British Somaliland, mentioned for the oil showings of Dagah Shabell, conditions are somewhat similar to those of Nigeria and the Gold Coast and the oil is found in shallow basins, among older formations, not favorable for commercial production.

Perhaps something similar can occur in the adjacent region of Abyssinia.

The problem is one of petroleum accumulation in basins, grabens, rifts—secondary deposits in narrow strips, sunk between parallel faults—zones where the earth-surface has been subjected to tensions instead of compressions.

The tectonics of fractures, though it may exclude the possibility of accumulation of large deposits, does not exclude that of small deposits, through the formation of "tertiary rifts," where younger strata have been deposited. In these strata petroliferous conditions favorable for petroleum genesis may have existed as is shown by oil exudations (like those observed in Abyssinia). Some of these exudations are remarkably numerous and definite, as on the coast of Lake Albert, which lies in a well defined rift.

It is not surprising, therefore, if the Abyssinian Rift presents similar phenomena, which account for the oil indications reported along it.

Consequently, it should be possible to find oil at shallow depth, but oil fields of great importance should not be expected, because the fundamental fact about the structures remains; that is, where there is tension, compression is absent. Therefore, the folding typical of the younger extensive and uniform strata is absent and there are no broad anticlines and unbroken domes.

IV

We remember that oil deposits originate in littoral zones bordering large rift basins, consequently the distribution of deposits is in relation

with the distribution of the land and water during the various geological epochs. This paleogeographic relation is so constant that it is an important guide in oil exploration.

The most numerous and the richest oil-bearing formations are found on the borders of geosynclines as is evidenced by the geographic distribution of the principal oil fields of the world.

However, outside the borders of geosynclines some oil accumulations are found in the rift valleys of the foreland, if conditions of sedimentation and subsidence exist which are similar, though on a smaller scale, to those of the geosynclinal borders. This is what should be sought and examined carefully in the rift basins of Abyssinia. We might mention some "subsidence basins," but first the field conditions should be checked.

Perhaps subtabular deposits will be found, with reservoir rocks ranging from Triassic sandstones to young limestones and dolomites, and including fissured rocks and altered eruptives.

We add that the geosynclinal boundaries of large plateaux (as in Somaliland) may show folding which need not be the result of the ordinarily accepted causes of folding, since such ordinary origin must be excluded here because of the broad plateau structure.

Geosynclinal boundary structure has been recently demonstrated by W. A. Ver Wiebe.[5] Movements, displacements along geosynclinal basement faults, may cause folds in the sediments of the geosyncline without the action of tangential thrusts. Vertical movements of the blocks which are caused by buried faults may produce folds.

These results are of great importance, because they could be effective also on the western margin of the geosyncline of the African Coast which, according to Beeby Thompson and Grindley Ferris of The Inyaminga Petroleum Limited, extends northward into Persia and west of Migiurtinia, touching also the coast of Somaliland. This limit includes the Eocene ambient of Migiurtinia.

The bathymetric map of the Indian Ocean by G. Schott[6] shows north of Madagascar, the "Somalimulde," probably a tectonic graben.

A careful search should be made along the Migiurtinia-Somaliland coast, the western limit of the Indo-Ethiopic geosyncline, and in the Eritradic rifts and grabens.

V

Exploration in the Dahalak Islands is justified by the oil showings in the sea and by other indications.

[5] W. A. Ver Wiebe, "Geosynclinal Boundary Faults," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 7 (July, 1936), pp. 910–38.

[6] G. Schott, *Geographie des Indischen und Stillen Ozeans.*

The possible conditions of the immediate subsurface may be considered not too unlike conditions of the adjoining orographic masses of Dankalia, where, under cover of effusive rocks, lie previously folded beds of Mesozoic and Cenozoic age.

However, in the Dankali Alps, which are predominantly Mesozoic sedimentary rocks and lava cover, with limited outcrops of a deeper crystalline basement, the structure is very complicated and does not have reliable oil possibilities; nevertheless, oil possibilities do exist in the postulated outer marginal folds, of which the Dahalak Islands should be the visible and emerged example.

We call attention to the Dankali graben, a littoral graben with Neogene sedimentary rocks on the surface.

If petroleum can originate at the boundaries of eroded masses and of shallow seas, in coastal lagoons, at the mouth of estuaries and deltas, in warm climates, which involve frequent and strong variations of salinity, the Dankali graben must be taken into consideration in the search for petroleum.

The Arabian tableland bears numerous peri-alpine indications of oil, for example, in Syria and in Palestine, but the only exploited deposits are those that border the Suez Canal, on the Asiatic side and on the African side. Though comparison with the potential deposits of the Dahalaks and of Dankalia can not be made, nevertheless it may be remarked that their type does not differ from that of the Eritradic and Berbera deposits.

The oil possibilities of the Harrar district are least, as there are no structures paralleling the large fractures, which caused difference in level between the lifted masses of the Harrar plateau (with outcrops of Archean granitic rocks) and the depression of the Awash, filled with old and recent lava flows.

There are large erosional windows, in which the Jurassic series (which should have acted as a more or less impermeable cover) has been uncovered by fluvial erosions, which also deepened themselves through the arenaceous series of Triassic rocks widely uncovering the Archean crystalline basement.

Structural deformation is everywhere absent, even in the Triassic arenaceous-schistose outcrops, which seem discordant on the crystalline rocks and which are noticed in many places.

The Ogaden is a marginal ambient with regard to the greater superelevation of the Harrar plateau relief, which slopes slightly toward the Somali littoral, with Jurassic and Cretaceous surface covers. It is a marginal area, not an outer, slightly folded, margin of belts of alpine, dinaric, andean type, but a margin of an intensely fractured tabular zone.

Paleogeography seems to reveal undulations in Middle and Lower Mesozoic, but these dates are very uncertain and, in the writer's opinion, the problem is always one about pseudoplicative repercussions of fracture tectonics.

It should be noticed that in Ogaden Cretaceous-Jurassic sediments replace the Tertiary cover which forms the surface in British Somaliland.

In Ogaden, the generally accepted favorable criteria in petroleum geology are not observed. There are no sunken areas, no slightly folded areas, no outer margins of more intensely folded belts, no geosynclinal borders, no ambients of accumulation of large sedimentary masses, free, or almost free, from the intervention of endogenous factors. There is, however, a preponderance of old and recent eruptive flows in the complex of rocks, which share in the formation of that intensely fractured subsurface.

In the depression of the Awash—part of the great African graben—the immediate subsurface is predominantly lava flows which extend beyond the limits of the depression in the territory of Aussa and along the western side of the Dankali depression.

With the previously mentioned principles of petroleum origin and structure in mind, it may be said that the territory of Aussa deserves nevertheless an attentive examination.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 21, NO. 3 (MARCH, 1937), PP. 299-310, 9 FIGS.

GEOLOGY OF THE COAST OF THE STATE OF ALAGÔAS, BRAZIL[1]

VICTOR OPPENHEIM[2]
Rio de Janeiro, Brazil

ABSTRACT

This brief article covers the writer's general survey of the coast of the state of Alagôas, in May, June, and July, 1933, and has been partly published in Portuguese.[3]

The sedimentary belt along the coast of Alagôas is the only area in the state which can be considered as offering some interest from the point of view of petroleum geology. It is limited on the west by the extensive area of basement granites and gneiss which form the rest of the state.

Since 1920, 10 wells have been drilled in the Riacho Doce area on the coast of Alagôas. A study of the logs of these wells permits a modification of the previous opinions of Branner and E. Oliveira which were based only on surface observations.

The formations of the sedimentary belt are Tertiary in age. The upper strata, called the Barreiras formation, form extensive red bluffs along the coast; they are poorly stratified and non-fossiliferous. The lower strata, consisting of the gray and dark shales of the Alagôas series, have been paleontologically classified as Eocene. These shales are partly bituminous and are the only known rocks in the state here considered as possibly oil-bearing. Structurally, the shales of the Alagôas series are disturbed, tilted and broken.

The writer, after studying the outcrops and the logs of wells in the Riacho Doce area, admits the possibility of existence of oil in the Alagôas series, but considers the general conditions as somewhat unfavorable for the development of important production. He concludes that a deep test well is desirable, mainly for study purposes, in the most favorable locality and recommends a geophysical survey of the area. The latter is now being made.

INTRODUCTION

Outcrops of bituminous shales along the coast of the state of Alagôas have been known for many years, the inhabitants using the material as fuel. Several enterprises have been founded on the commercial oil possibilities of these shales. Prior to the time of the writer's survey in 1933, however, no complete study of this supposedly petroliferous area had been made.

Apart from the notes of Derby and Hartt, the only important studies of the region are those of John C. Branner[4] in 1900 and 1910 and those of the Brazilian Government Geological Commission in

[1] Manuscript received, January 9, 1937.

[2] Consulting geologist, Avenida Pasteur 404.

[3] Victor Oppenheim, "Possibilidades da existencia de petroleo em Alagôas," *Mineração e Metallurgia* (Rio de Janeiro), Vol. 1, No. 1 (May–June, 1936), pp. 26–32.

[4] John C. Branner, "The Oil-Bearing Shales of the Coast of Brazil," *Trans. Amer. Inst. Min. Met. Eng.*, Vol. 30 (1900), pp. 537–54.

——, "The Geology of the Coast of the State of Alagôas."

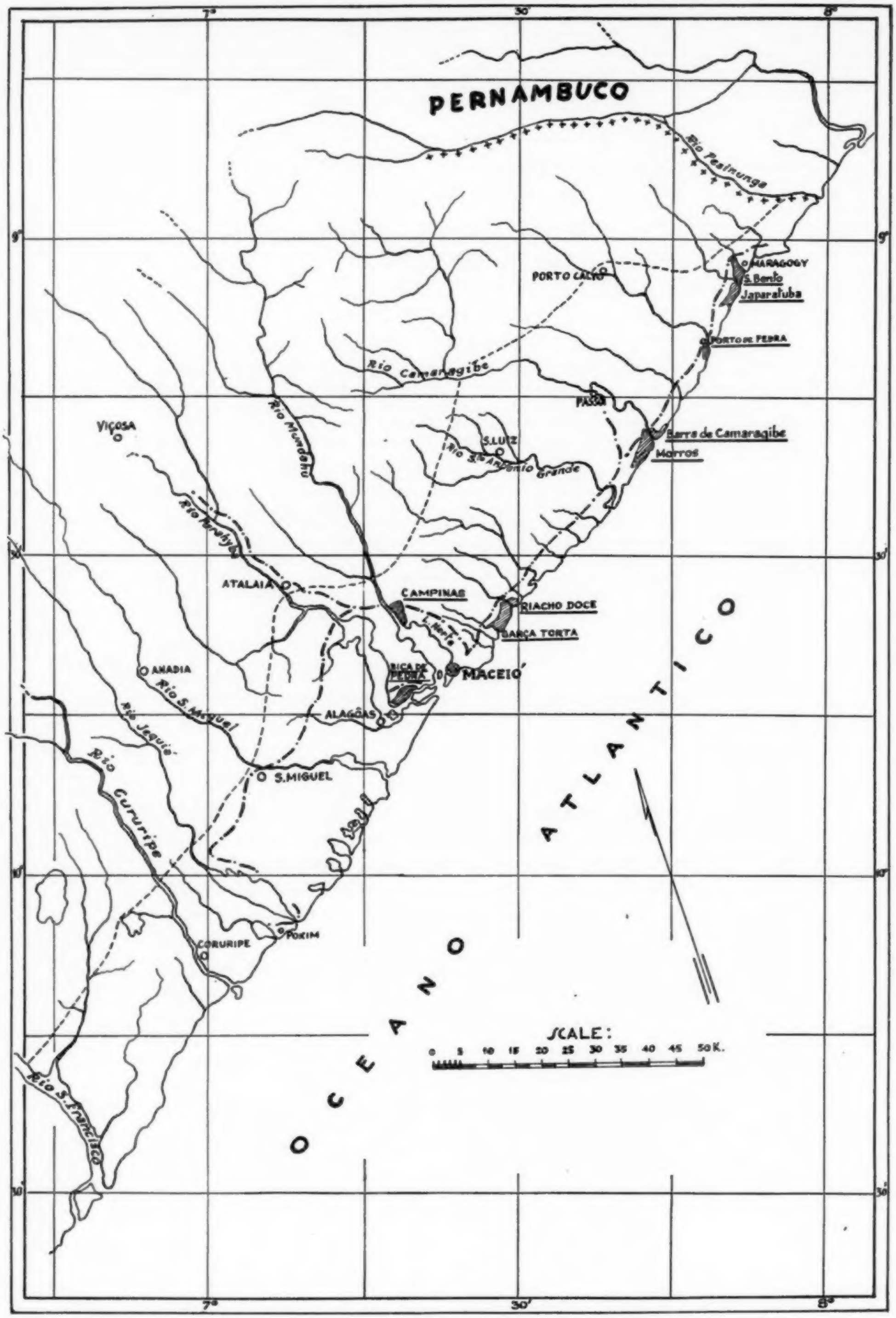

FIG. 1.—Map of coast of state of Alagôas, Brazil, showing by diagonal shading known outcrops of shales of Alagôas series (Lower Tertiary).

1918.[5] Branner's articles, although correct as regards the surface geology, err in the structural interpretation of the coastal belt.

The Brazilian Government survey under E. Oliveira in 1918 merely confirmed what was already known on broad lines as the result of earlier observations. Unfortunately, the data on the tectonics of the coast given in the Commission's report were not correlated, and the inferences essential for a complete study from the point of view of petroleum geology were consequently lacking. The ten holes drilled since 1920 by the Government and by private concerns in the Riacho Doce and Garça Torta area were shallow and insufficiently studied at that time.

For assistance in preparation of this article the writer is indebted to I. Burbridge.

PHYSIOGRAPHY

The coast of the state of Alagôas stretches from latitudes 8°55′ to 10°30′ S. The general topography shows an abrupt transition from the hilly region covering all the west part of the state to the flat coastal belt in the east. Farther east, the coastal plain ends abruptly, at some places in the sea, but for the most part in a line of bluffs ranging from a few meters to several kilometers from the coast line.

These three topographical divisions—the hilly Archean area, the coastal sedimentary plain, and the coast itself—are well defined and geologically distinct.

The coastal plain is drained by streams whose general direction is southeast. The rivers rising in the hilly region beyond the plain maintain an even flow throughout the year, but the volume of water in the coastal streams is uncertain and varies with the season. The vegetation of the plain is sparse and not well developed and contrasts strongly with that of the hilly region.

For the most part the western limit of the coastal plain is nearly parallel with the coast line, the plain bordering the hilly basement area 10–30 kilometers from the coast. Beyond the plain, the whole state, as far as the borders of the neighboring states of Sergipe and Pernambuco, appears as a region of deeply eroded basement rocks.

GEOLOGY

The geology of Alagôas has already been described on broad lines by the previously mentioned authors.

The Archean formations cover most of the state as far as its fron-

[5] Eusebio de Oliveira, "Rochos petroliferas do Brazil," *Serv. Geol. Min. Brazil Bol.* *1*(1920).

tiers in the west, north, and south, but they are bordered in the east and southeast by the sedimentary plain.

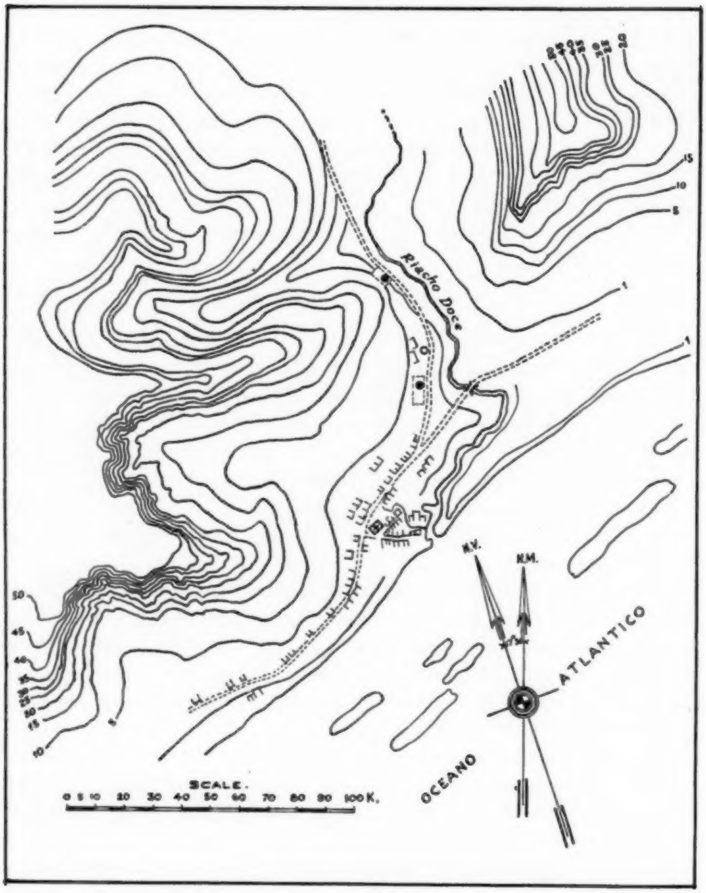

FIG. 2.—Topographic sketch of area of wells in Riacho Doce, Alagôas. Contour interval, 5 meters. Solid black dots, drill holes of Cia. Petroleo Nacional, S. A. Open circle, abandoned Government location.

In the Riacho Doce area the nearest Archean basement rocks form outcrops in the west at Cachoeira de Mirim. The line of contact extends farther south at approximately 20 kilometers from the coast,

and crosses the River Parahyba at Atalaia, approximately 35 kilometers from the sea. The crystalline rocks are mainly granites of medium-to-coarse texture, or gneiss.

The sedimentary plain with its bluffs, called the Barreiras formation, forms a belt 20–30 kilometers wide along the coast. It is bounded in the north by the basement rocks at Persinunga, and in the south by the São Francisco valley with its Cretaceous or possibly Triassic formations.

The extensive line of bluffs 40–80 meters high, with exposed erosion cuts, is characterized by vivid red coloring. The formation ex-

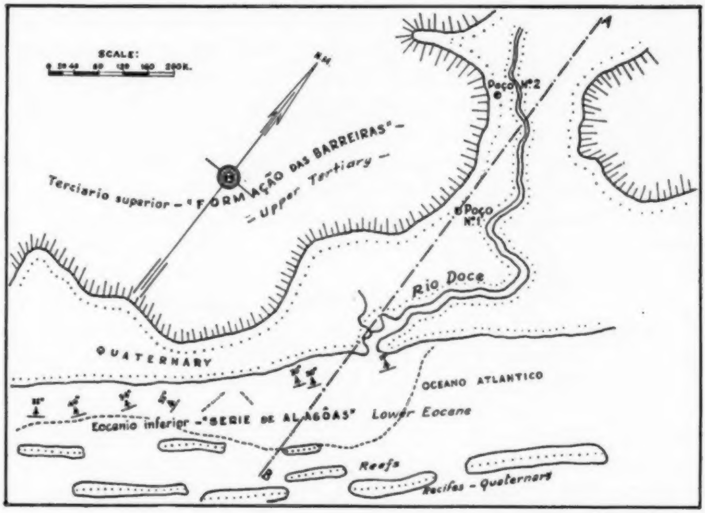

FIG. 3.—Geologic sketch map of Riacho Doce, showing location of cross section *AB* (Fig. 4).

posed in the bluffs, although poorly stratified, dips very slightly toward the west. Lithologically, the bluffs are composed of successive thin layers of loose sandstones, clays, and some shales.

Although the absence of fossils in the Barreiras formation makes an accurate classification somewhat difficult, a lithologic correlation shows it to be undoubtedly Tertiary. Branner placed the formation in the Eocene, but E. Oliveira[6] places it in the Pliocene. The formation is evidently Upper Tertiary, most probably Pliocene, and rests discordantly on much older shales of the Alagôas series.

[6] E. Oliveira, "Geologia historica do Brasil," *Serv. Geol. Min. Brasil* (1931).

In a distance of 110 kilometers along the coast, from Maragogy in the north to Bica da Pedra in the south, and widely separated from one another, outcrops of shales are in some places bituminous. Most of these outcrops are visible and accessible only at low tide.

Basing his classification on the numerous fossils, fishes, molluscans, and diatoms, Branner identified these shales as Lower Tertiary, Eocene, in age. The known fossils are mostly of the genera *Chiromistus*, *Dastilbe*, *Estheria*, et cetera of the Lower Eocene.

The Alagôas series, as these shales are known, consist of a succession of gray or greenish hard thin shales, bituminous shales, bluish clays, thin sandstone layers, and thin beds of limestone or shaly sandstone in some places containing asphaltic impregnations. These outcrops are in some places overlain by fairly large boulders of basement gneiss and granitic rocks which, by their position and size, seem to have come from an area not far from their present site. Whether they came from the basement rocks in the west, where the latter form extensive outcrops, or whether they originated in an area in the east that was subsequently, and still is, covered by the ocean, is an open question. However, the pronounced westerly dip of the beds favors the hypothesis of their having come from some elevated, now submerged, landmass in the east.

From south to north along the coast the locations of the outcrops of the main Alagôas series known and visited by the writer are: Bica da Pedra, Campinas, Garça Torta, Riacho Doce, Camaragibe, Porto de Pedra, Japaratuba, Maragogy, and São Bento.

The Alagôas beds were evidently deposited under lacustrine brackish-water conditions, the thin successive layers of shales, limestones, and sandstones corresponding to different periods of deposition.

The asphaltic impregnations of the limestones and the bituminous shales, interpreted by some authors as due to deep oil accumulations, may be explained simply as the result of local metamorphism of the shales of the series, rich in vegetable and animal organic remains.

Beyond the shale outcrops, and parallel with the whole coast of the state, there is a long broken line of reefs of coarse sandstone cemented by limestone and shell remains. These reefs, which are of Recent and present formation, are partly covered with corals.

TECTONICS

The general aspect and disposition of the observable outcrops of the Alagôas series suggest several structural elevations of which the outcrops are the summits. They show the effects of considerable erosion which preceded the deposition of the Barreiras formation. The

strike of the strata is variable, although mainly northeast with a pronounced westerly dip.

When considered in conjunction with the extent of the sedimentary belt, the dips of most outcrops confirm the evidence of thinning beds and limitation of the basin toward the north, ending at the Persinunga basement outcrops on the frontier of the state of Pernambuco.

Apparently, Bica do Pedra is the most southerly outcrop of the series, and the Cretaceous-Triassic basin in the Penedo area, with its extension under the Barreiras formation, forms the natural southern

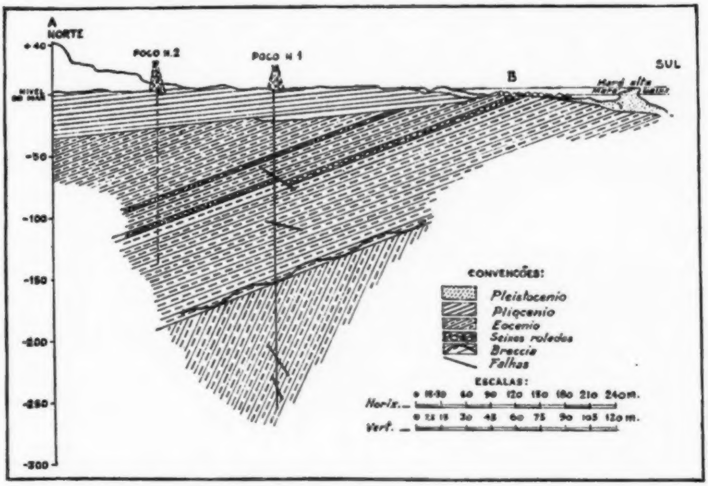

FIG. 4.—Schematic north-south cross section *AB* (Fig. 3). Some outcrops are observable only at low tide.

limit of the Alagôas series. In spite of being much twisted, tilted, and highly disturbed, the outcrops of the Riacho Doce area show a distinct northwesterly dip. The wells drilled in this area confirm the presence of local structural discordances. The outcrops at Camaragibe show a narrow anticlinal fold whose axis strikes north-northeast. On the whole, the observable outcrops of the series along the coast are doubtfully representative of favorable structure. The Camaragibe area shows the best structural conditions, and a closer study of this area should be of interest.

The several outcrops of the series at São Bento and Japaratuba in the Maragogy district appear to form a syncline. The sediments in this area are apparently of no great thickness, for the basement rocks are only approximately 5 kilometers distant on the west and north.

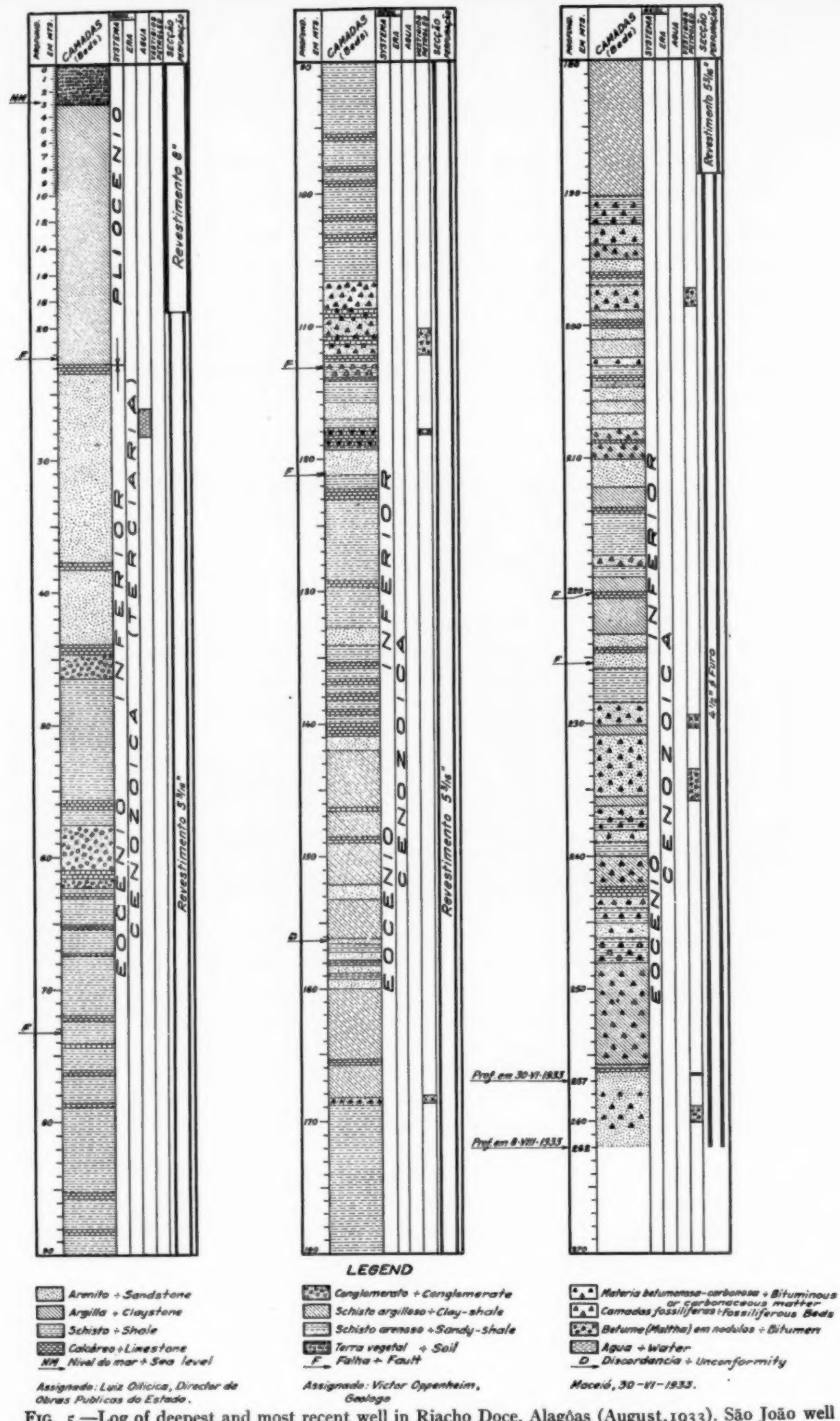

FIG. 5.—Log of deepest and most recent well in Riacho Doce, Alagôas (August, 1933). São João well of Cia. Petroleo Nacional. Depth, 262 meters (860 feet).

As the Brazilian Government and certain private interests had already drilled several holes in the Riacho Doce district, this was the area studied in some detail by the writer. However, this region is geologically and structurally characteristic of the other coastal belt outcrops of the Alagôas series, and the data obtained may therefore be taken as representative.

An analysis of the cores from the wells in the Riacho Doce shows the presence of many small faults and dislocations of strata with slight vertical projection, as well as highly contorted beds with occurrence

FIG. 6.—Outcrop of basement rocks in western part of Alagôas.

of breccia and structural discordances. Taking into consideration the dips of the strata, their structural character, and the presence of beds of boulders of basement rocks, the writer assumed a thickness of approximately 600 meters for the Alagôas series in the Riacho Doce area, this figure being considerably higher than that of only 80 meters previously given by Branner and Oliveira.

The geophysical survey of the Alagôas coast now being made by the Government shows the topography of the basement rocks below the sediments to be very irregular, although the sediments in places show a thickness of 1,000 meters and more in the Riacho Doce region. These data, however, have still to be confirmed by deep drilling in the future.

In the last drilling at Riacho Doce, studied by the writer in 1933, the cores showed a marked discordance in the strata, preceded by a layer of breccia, and of sandstones and shales at a depth of 156 meters. The strata underlying this nonconformity are lithologically identical with those above, and are thus presumably of the same age.

When the writer's report was presented in July, 1933, not all the data connected with the Riacho Doce drilling were available. Thus, the salt water found in the well at 257 meters was sea water which had penetrated during the drilling operations; it was not connate with

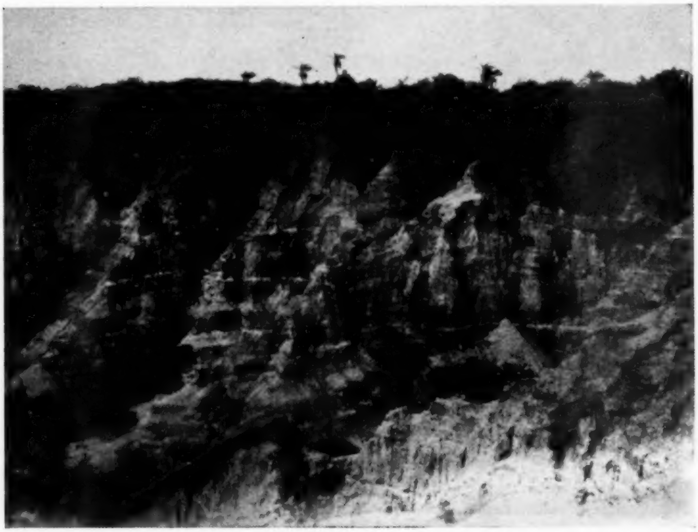

FIG. 7.—Barreiras formation on the coast of Alagôas.

the formation of the Alagôas series shales. Furthermore, at lower depths down to 262 meters, the cores showed abundant vegetable and lignitic remains, thus proving that not only the outcrops, as Branner stated, but also the deeper strata are evidently of a brackish-, fresh-water origin.

OIL PROSPECTS

The coastal sedimentary belt is rather extensive and the Alagôas formation, containing bituminous shales and showings of asphalt in the wells, makes it of speculative interest as regards possible petroleum occurrences. However, the brackish-, fresh-water origin of the sediments, the lack of important porous sandstone beds which could

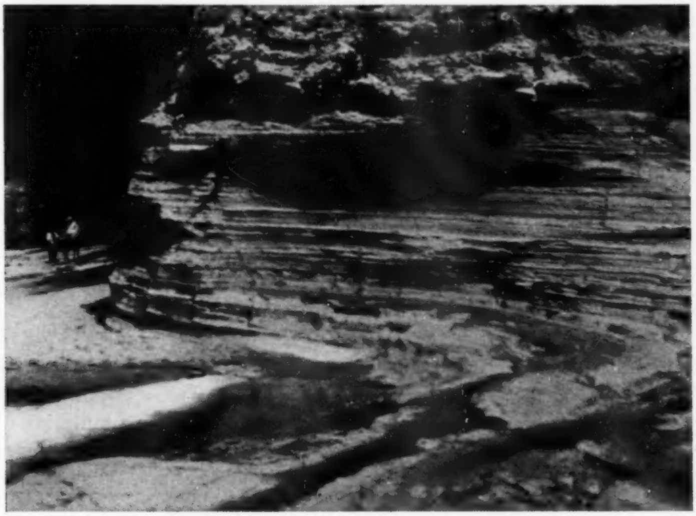

FIG. 8.—Shales of Alagôas series at Camaragibe, Alagôas.

FIG. 9.—Outcrops of shales of Alagôas series near Riacho Doce, Alagôas.

act as a reservoir for large accumulations of oil, the apparent absence of a cover-bed, and finally the lack of proper structural conditions make such possibilities in the Riacho Doce area relatively doubtful.

Camaragibe, or some locality south of Riacho Doce, would be a region with more favorable structural conditions. A detailed study of these areas, followed by a test well, might be of interest. Even here, though, conditions are unfavorable for possibly large accumulations of oil. Nevertheless, a porous formation different from that observed in the outcrops and in the few wells may be found at greater depths, thus rendering possible the occurrence of oil accumulations more important than the few showings of asphalt encountered at various depths in the Riacho Doce well.

In 1933 the writer recommended a geophysical survey of the coast, together with a deep well. The former is now being carried out. The preliminary geophysical work has confirmed the writer's opinion that the Riacho Doce area is structurally unsuited to the accumulation of oil. Unfortunately, no drilling has been done in recent years in more favorable localities along the coast, as advised. These are now planned by the Government and will be of geological interest.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 21, NO. 3 (MARCH, 1937), PP. 311-316, 2 FIGS.

SUBSURFACE DISTRIBUTION OF HAMILTON GROUP OF NEW YORK AND NORTHERN PENNSYLVANIA[1]

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Coudersport, Pennsylvania, and Wellsville, New York

ABSTRACT

The rocks of the Hamilton group crop out in a narrow belt in New York and Pennsylvania, which forms a great semi-ellipse extending from Lake Erie in the vicinity of Buffalo eastward to the Hudson River valley near Albany, thence south and southwest into Pennsylvania and New Jersey near Port Jervis, New York, and thence by the curving highly folded Appalachian belt westward and southwestward through Pennsylvania into Maryland. The area within this semi-ellipse is approximately 250 miles east and west and 125 miles north and south.

The Hamilton is buried under younger Devonian rocks within this area and practically no information was available concerning its character until the discovery of natural gas in the Oriskany sand in Schuyler County, New York, and Tioga County, Pennsylvania, in 1930. Since then more than 100 scattered deep wells in southern New York and northern Pennsylvania have been drilled through the rocks composing this group from most of which samples of drill cuttings have been collected and described.

Studies of logs of these wells have revealed certain information about the Hamilton which will be of interest to those engaged in solving the complex problem of the lateral change in the Devonian strata in this region and of usefulness to those geologists engaged in the oil and gas industry.

The Hamilton in New York and Pennsylvania has been the subject of much local investigation and many publications beginning with Hall and Vanuxem of the First Geological Survey of New York between 1837 and 1843, followed by Clarke, Beecher, Prosser, Luther, I. C. White, and others and more recently by Chadwick, Cooper, Willard, and others. However, little had been published presenting a picture of the regional stratigraphy of the Hamilton until Cooper's[4] papers of 1930 and 1933 in which he presented measured sections and unit correlations across 260 miles of the outcrop belt in New York. Willard and Cleaves[5] have begun a study similar to that of Cooper which it is hoped may be enlarged to include all of the state.

The data presented here bridge a large part of the gap from the outcrops in central New York and central Pennsylvania, at least, inso-

[1] Published by permission of the Penn-York Natural Gas Corporation and H. L. Doherty and Company. Manuscript received, December 21, 1936.

[2] Penn-York Natural Gas Corporation.

[3] Empire Gas and Fuel Company, Ltd.

[4] G. Arthur Cooper, "Stratigraphy of the Hamilton Group of New York," Parts 1 and 2, *Amer. Jour. Sci.*, Vol. 19 (February and March, 1930).
——, "Stratigraphy of the Hamilton Group of Eastern New York," Parts 1 and 2, *Amer. Jour. Sci.*, Vol. 26 (December, 1933) and Vol. 27 (January, 1934).

[5] Bradford Willard and Arthur B. Cleaves, "The Hamilton Group of Eastern Pennsylvania," *Bull. Geol. Soc. America*, Vol. 46 (1933).

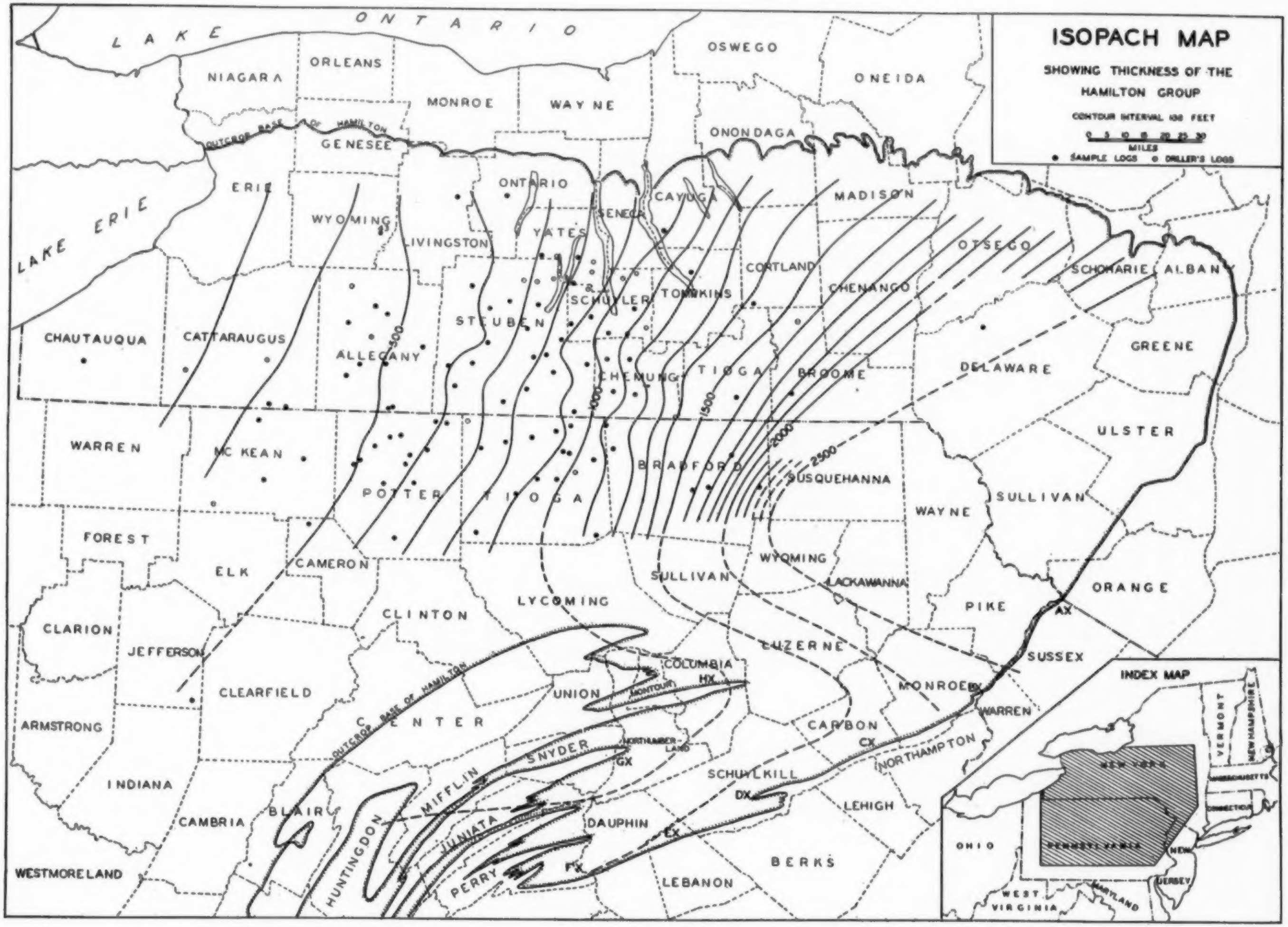

FIG. 1.—Isopach map sh owing thickness of Hamilton group, accompanied by index map.

far as the thickness and general lithologic character of the Hamilton is concerned.

In this paper there is included in the Hamilton all of that section from the base of the Tully, or in its absence, the base of the Genesee, to the top of the Onondaga. Correlations of the Tully and Onondaga have been made entirely on the basis of lithologic features and by the use of sample well logs in cross sections traversing the area in different directions, each section beginning with definitely known outcrops. Both formations are easily recognized in sample well logs. In practically all of the area covered by the isopach lines of Figure 1 the Tully is present. This formation at its type locality in the Finger Lakes region of central New York is fine-grained, hard, blue limestone, 10–30 feet thick. Under the surface from western New York, where it is generally absent, it gradually increases in thickness southeast toward Bradford County, Pennsylvania, where it was found to be 118 feet thick in a well drilled in Stevens Township. With its increase in thickness the formation becomes darker and more argillaceous, to such an extent that it hardly can be called limestone. Its demarcation from the overlying black Genesee shale is sharper than from the underlying Moscow shale. In central Pennsylvania the Tully is doubtfully present, at least as the lithologic unit known farther north.

At its outcrop the Onondaga in western New York is blue-gray, thin-bedded limestone containing nodular chert and ranges in thickness from 80 to 100 feet. These characteristics are generally maintained in eastern and southeastern New York except that the limestone becomes more massive and somewhat thicker. In central Pennsylvania it is generally less than 50 feet thick and consists of dark argillaceous limestone interbedded with dark calcareous shale.

Under the surface in western New York and Pennsylvania the Onondaga is 200 feet thick and is generally gray-to-white cherty limestone decreasing in thickness and changing in character along the line of the two states to Tioga County, Pennsylvania, where it has become dark gray argillaceous limestone devoid of chert and with a thickness of approximately 20 feet. It is very similar to the Onondaga as seen in many places in Columbia County, Pennsylvania. This same character is maintained into Bradford County, Pennsylvania, where Esopus or Schoharie beds begin to develop between the Onondaga and Oriskany.

The logs of several wells in certain gas pools have not been considered in making the isopach map because of an abnormal thickness of the Hamilton due to duplication of section and crushing and adjustment caused by faulting.

FIG. 1.—Isopach map showing thickness of Hamilton group, accompanied by index map.

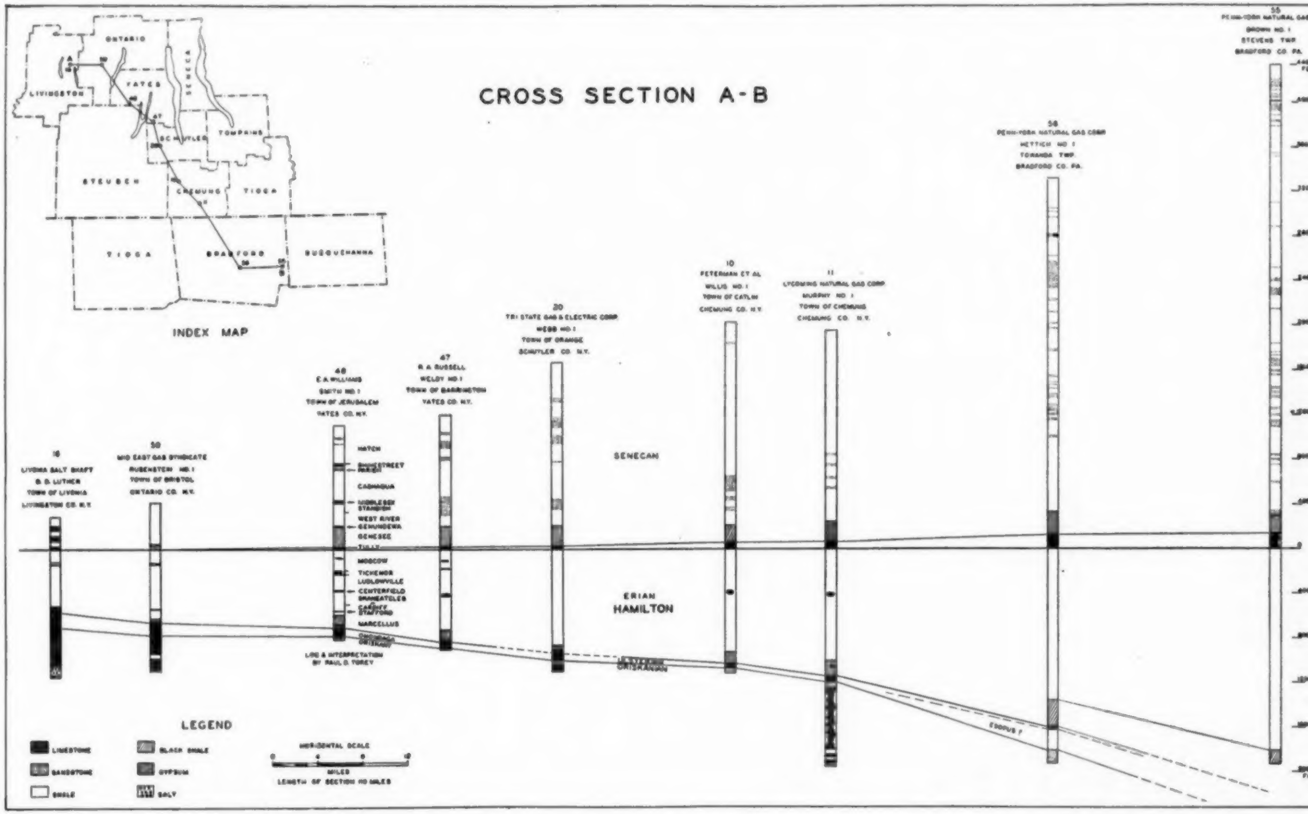

FIG. 2.—Cross section from Livingston and Ontario counties, New York, southeast to Bradford County, Pennsylvania, accompanied by small index map.

From a three-dimensional standpoint, as now established by subsurface data, the Hamilton in this area is almost a perfect wedge without major irregularities except in Columbia and Northumberland counties, Pennsylvania. The thickness increases in a direction S. 10° E. from 250 feet in western New York and Pennsylvania to approximately 2,225 feet in Stevens Township, Bradford County, Pennsylvania, a distance of about 180 miles. Cooper's[6] sections indicate that the thickness along the outcrop belt in central New York increases eastward from 285 feet at Lake Erie to 2,450 feet in the Schoharie valley, a distance of 260 miles. In northeastern Pennsylvania Chadwick[7] reports the Hamilton to be 2,375 feet thick on the Delaware River in Monroe County and 1,760 feet thick on the Lehigh River in Carbon County. Farther southwest, Willard and Cleaves[8] show the thickness to decrease from 1,895 feet in Schuylkill County to 1,500 feet in Perry and Dauphin counties. In Northumberland County, Pennsylvania, Willard[9] has measured the thickness of the Hamilton as 785 feet and in Columbia County, White[10] gives the thickness as 810 feet. Compared with 2,225 feet 50 miles north and with 1,500 feet 50 miles south, the thickness of the Hamilton in this locality seems to be abnormally small, especially in view of the absence of such irregularities elsewhere in the whole region. Farther west in Pennsylvania, in Blair and Huntington counties, Butts[11] gives the thickness of the Hamilton as 950–1,350 feet and incidentally suggests the Tully to be represented by 1 foot of limestone containing *Chonetes aurora*.

Again considering the Hamilton tri-dimensionally, the rate of thickening increases from about 8 feet per mile in western New York and Pennsylvania to over 80 feet per mile in Bradford County, Pennsylvania.

The isopach lines indicate that the greatest thickness of the Hamilton is in the Catskill region of southeastern New York where it may reach 3,500 feet or more. Toward this area the Hamilton rapidly increases in thickness and most of the section of dark and gray shales becomes sandy shale and sandstone. This area probably represents the

[6] G. Arthur Cooper, *op. cit.*

[7] George H. Chadwick, private report prepared for H. L. Doherty and Company, 1931.

[8] Bradford Willard and Arthur B. Cleaves, *op. cit.*

[9] Bradford Willard, "The Devonian Section at Sellinsgrove Junction, Pennsylvania," *Amer. Nat.*, Vol. 13, No. 4 (July, 1932), p. 224.

[10] I. C. White, *Sec. Geol. Survey Pennsylvania Rept. G 7*, p. 225.

[11] Charles Butts, "Geologic Section of Blair and Huntingdon Counties, Central Pennsylvania," *Amer. Jour. Sci.*, Vol. 46 (September, 1918).

deepest part of the Devonian basin that existed during Hamilton times in this region.

Cooper[12] has divided the Hamilton of New York into four formations and several subdivisions as follows.

Moscow formation	Windon shale Kashong shale Menteth limestone	Portland Point limestone
Ludlowville formation	Deep Run shale Tichenor limestone Wanakah shale	King Ferry shale
	Ledyard shale Centerfield limestone and sandstone	
Skaneateles formation	Levanna shale	Berwyn shale and Colgate sandstone Pompey shale and sandstone Delphi shale and sandstone
	Stafford or Mottville limestone and shale	
Marcellus formation	Cardiff shale	Peckport shale Sollsville sandstone Bridgewater shale
	Oatka Creek shale	Chittenango shale Cherry Valley limestone Union Springs shale and limestone

He has discussed the change in faunal and lithologic facies of each to which the reader is referred for a complete description.

Of all these Hamilton units only the Marcellus has been identified by the writers with certainty largely because its lower boundary is sharply defined and it maintains its black fissile character throughout the entire area of well-log data. The Cherry Valley limestone member of the Marcellus is commonly present in the western two-thirds of New York but not elsewhere. The Centerfield and Tichenor limestones are identifiable in some well logs in the central part of New York, but appear to be absent or too thin to be recognized in many wells.

The entire Hamilton section from Lake Erie to the central Finger Lakes area is composed of black and dark gray argillaceous shales with a few thin limestone and sandstone beds. At the longitude of the central Finger Lakes area the middle part of the Hamilton, probably the Ludlowville, begins to change into light sandy shales and sandstones, the prevalence of which rapidly increases from top to bottom of the section to such an extent that nearly all of the Hamilton has changed to gray sandstones and dark gray sandy shales in Delaware County, New York. Along the outcrop from central to northeastern Pennsylvania and the outcrop from Lake Erie to Albany County, New York, the same condition prevails, pointing to the Catskill area as being the focal center of Hamilton deposition in the north Appalachian region.

[12] G. Arthur Cooper *op. cit.*

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 21, NO. 3 (MARCH, 1937), PP. 317-332, 3 FIGS., 2 PLATES

INSOLUBLE RESIDUES OF DUNDEE AND DETROIT RIVER (UPPER MONROE) FORMATIONS OF CENTRAL MICHIGAN[1]

DEAN C. WELLMAN[2]
Evanston, Illinois

ABSTRACT

Certain stratigraphic problems have arisen in the correlation and differentiation of the Dundee and Detroit River formations of central Michigan. One approach to the solution of the problem is by means of insoluble residues. A convenient insoluble-residue method applicable to this problem is developed, and both quantitative and qualitative data obtained indicate that this method can be used as an aid in the differentiation and correlation of these formations.

INTRODUCTION

The correlation of the formations of Michigan is a difficult problem for the stratigrapher. It has been possible by means of fossils only locally in the restricted areas where the formations crop out, and these are far from the central Michigan area where definition is most desired for oil-field development. As there is a thick cover of drift in this part of Michigan, subsurface work is necessary, and lithologic features as shown by well cuttings have been generally used in correlation. These have been sufficient in many places where the formations exhibit distinctive lithologic character in wide areas, but where adjacent formations such as the Dundee and Detroit River are similar lithologically the method has not always met with success. Furthermore, there is no definite method for the location of horizons within the Dundee, which is highly desirable as this formation is the chief source of petro-

[1] Manuscript received, November 25, 1936.

[2] Department of Geology, Northwestern University. This paper is based on a thesis submitted to the Graduate School of Washington University, St. Louis, Missouri, for the degree of Master of Science.

Acknowledgment is due Carl Tolman, of Washington University, for his supervision of the work involved in the investigation and for criticism of this manuscript. The writer is also indebted to H. L. Koch, of the Shell Petroleum Corporation, who originally suggested this study and contributed many samples used in the preparation of the insolubles; to G. E. Eddy and K. Gorton of the Michigan Geological Survey for the information concerning the wells dealt with in this study and for many well samples; to B. F. Hake and J. Maebius of the Gulf Refining Company, and W. A. Thomas, formerly of the Pure Oil Company, for samples and information; to R. S. Poor, of Birmingham Southern College, for information and criticism of this manuscript. The following kindly supplied information concerning the method of insoluble residues: W. L. Wilgus of the Shell Petroleum Corporation, L. E. Workman of the Illinois Geological Survey, and H. S. McQueen of the Missouri Geological Survey. To G. M. Ehlers, of the University of Michigan, the writer is indebted for information on the paleontology of the Dundee formation.

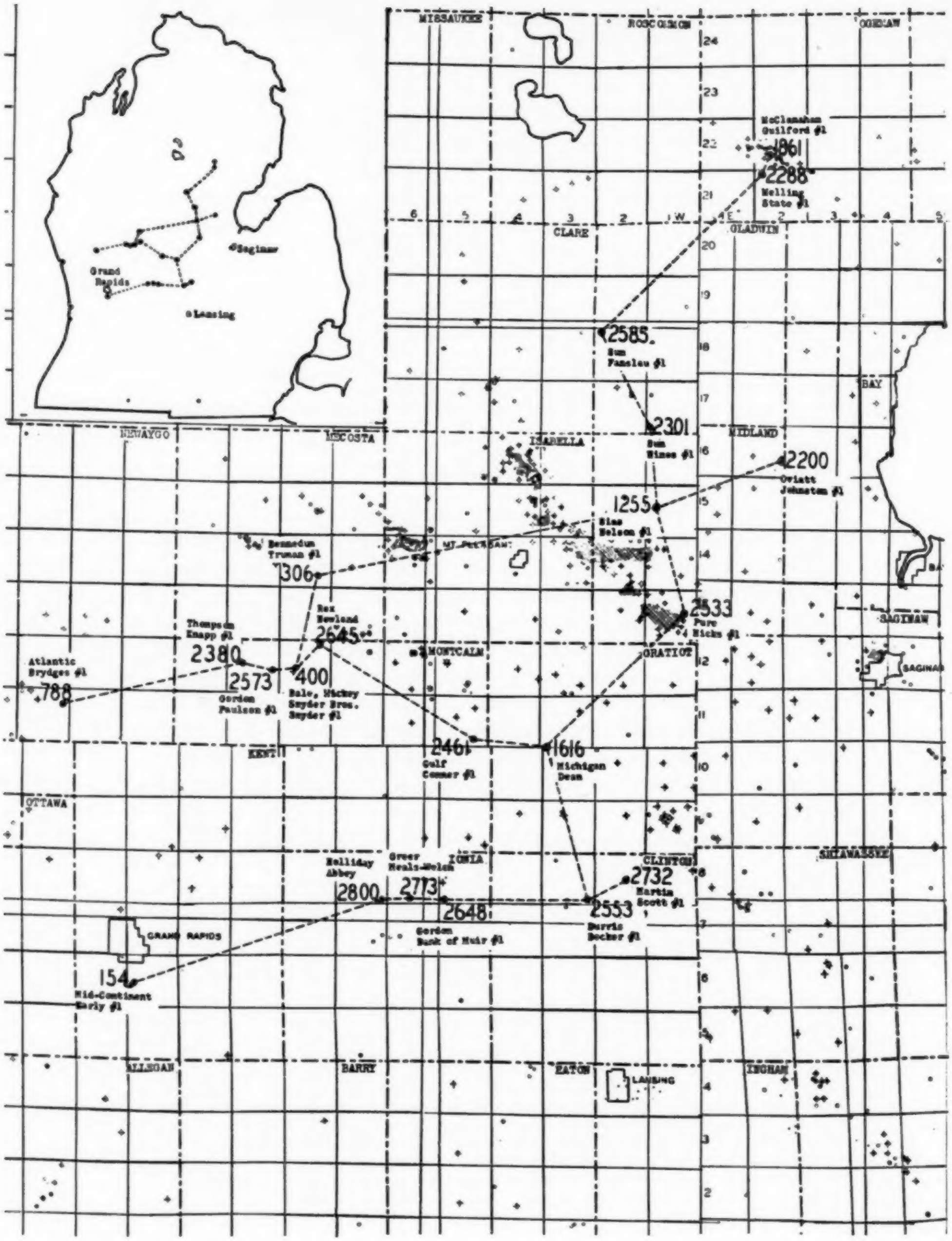

FIG. 1.—Map showing location of wells and horizontal sections compared, with index map showing their general location in Lower Peninsula of Michigan.

leum in this region. It was the purpose of this study to develop a method of insoluble residues applicable to the problem, in order to locate horizons and tentatively define the Dundee and Detroit River formations.

The distinction and correlation of the lower part of the Dundee and the Detroit River by means of insoluble residues has not been previously attempted; however, Eddy[3] has described residues from the upper Dundee from widely separated localities of the Lower Peninsula. Recent exploration for oil has made available material for a more intensive study of the upper Dundee, as well as lower parts of this formation.

The section taken for study lies in the Michigan Basin province, and includes an area more than 120 miles in maximum length and more than 60 miles in width, centrally located in the Lower Peninsula of Michigan (Fig. 1). Some refer to the district as the "Central Michigan oil fields," alluding to its recent oil developments. The area included was delimited by the locations of the wells from which the cuttings were obtained.

A generalized stratigraphic column for central Michigan is shown in Figure 2. The Detroit River formation of Lower Devonian (Heldebergian) age is composed largely of dolomite. It was first defined in southeastern Michigan as the upper Monroe,[4] and at this locality is 100–300 feet thick, representing only a small part of the formation. It rests unconformably on the Sylvania sandstone, also of the Lower Devonian, or where this is absent on the Bass Island (lower Monroe) of the Silurian. The Dundee formation was first defined by Lane.[5] In southeastern Michigan it rests unconformably on the Detroit River, and it is the opinion of many that this relation continues throughout most of the state. The Dundee at its type locality is relatively pure limestone, and the formation holding this stratigraphic position throughout the state is lithologically similar. It is believed, however, that the formation designated as Dundee in many parts of Michigan is not of the same age.[6] An unconformity separates the Dundee and Traverse formations of the Middle Devonian, as is evidenced by the

[3] G. E. Eddy, "A Study of the Insoluble Residues of the Lower Traverse, Bell, and Upper Dundee Formations of Michigan," *Papers Michigan Acad. Sci., Arts, and Letters*, Vol. 18 (1932), pp. 345–61. Published, 1933.

[4] A. C. Lane, C. S. Prosser, W. H. Sherzer, and A. W. Grabau, "Nomenclature and Subdivision of the Upper Siluric Strata of Michigan, Ohio, and Western New York," *Bull. Geol. Soc. America*, Vol. 19 (1908), pp. 553–56.

[5] A. C. Lane, "The Geology of Lower Michigan," *Michigan Geol. Survey*, Vol. 5, Pt. 2 (1893), p. 25.

[6] C. F. Basset, "Stratigraphy and Paleontology of the Dundee Limestone of Southeastern Michigan," *Bull. Geol. Soc. America*, Vol. 46 (1935), pp. 425–62.

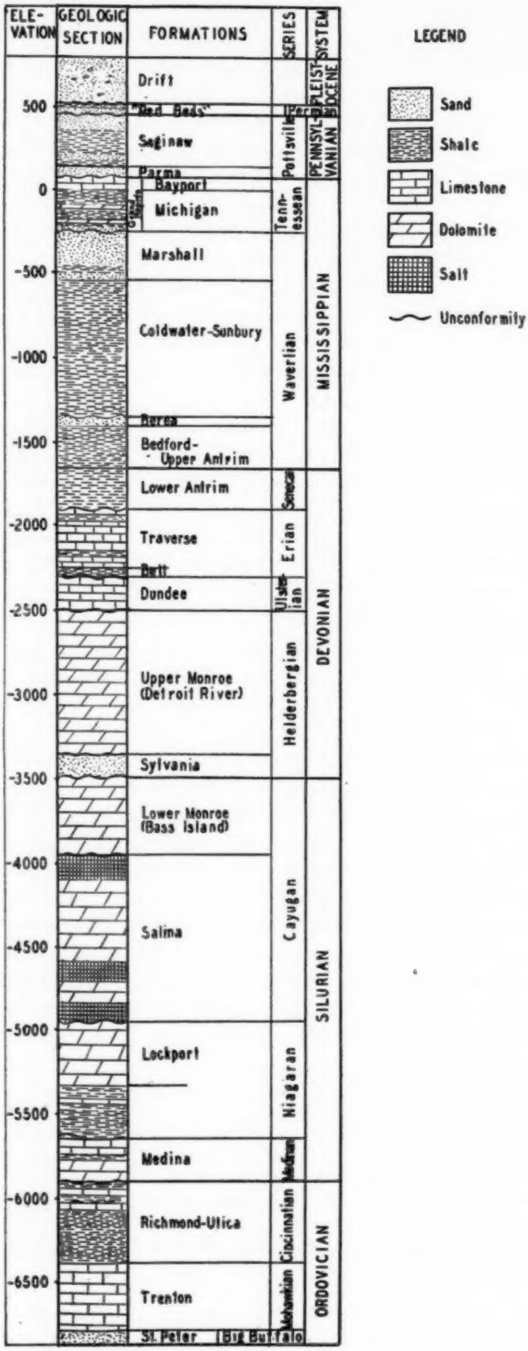

FIG. 2.—Generalized columnar section, showing vertical distribution of formations of central Michigan.

porosity of the Dundee formation and the apparent absence of this formation in some localities. The Traverse formation is composed of interbedded shales and limestones, the lowest member of which is the Bell, dark gray shale which is used as a convenient marker where present. All the formations of Michigan have a wide range in thickness due to the basin-type structure. In general, the thickest deposits occur where the basin was deepest during time of deposition, usually near the center of the Lower Peninsula, and thin laterally toward the boundaries. Thus within the area investigated the Dundee ranges in thickness from more than 300 feet to less than 100 feet, and the Detroit River from more than 1,000 feet to less than 700 feet.

METHODS EMPLOYED

The method employed in the analysis of limestone or dolomite by means of insoluble residues depends on the information desired. Much relating to the origin of sediments can be interpreted from qualitative data, while correlation is best based on both qualitative and quantitative data. For either object it is necessary to obtain a residue consisting of a concentrate representative of the horizon from which it was taken. The methods employed in this analysis were developed with this end in view.

Because the technique of preparing insoluble residues for study has not been thoroughly standardized for all conditions, the method used is outlined in this paper. It appears that the procedure used in one region is not entirely applicable to another where the conditions of sampling, stratigraphic relations, and composition of the formations are different.

Sampling.—All of the samples used in this study were cable-tool drill cuttings, no outcrop samples being available in central Michigan. More than 600 samples were taken from 21 wells as equally distributed as possible, the number of wells and their locations being determined by the availability of samples, the depth of drilling, and the discretion of the operators in the location of their wells. In the process of drilling the movement of the drilling tool and cable causes a certain amount of caving of the formations being penetrated, and of overlying formations, so that many cuttings become contaminated. Fortunately the formations of Michigan do not cave easily, but it is well to bear in mind such contaminations as a possible source of error in insoluble residue analysis.

Preparation of samples.—It was found convenient to use a large number of 250-cubic centimeter glass containers so that several steps could be carried on without loss of time. A metal tray was provided,

which held 24 of the containers, so that they could be handled more efficiently and many samples treated at one time. The containers were numbered with a tungsten carbide pencil and their weights recorded. The recorded weights were used throughout the procedure. Weighing material in the beakers was found to be much more convenient than by any other method.

A 10–15-gram portion of the cuttings was taken as a convenient standard amount, depending somewhat on the quantity available. Amounts as small as one gram were used in several instances. Obviously, the greater the size of the sample the greater the accuracy in the results. The sample was poured from its original cloth or paper container at random; a random sample (regardless of grade size) has been found by Wilgus[7] to give the most accurate and representative results for the percentage of insoluble residue.

The accuracy of the method was tested by the writer from separate portions of the same lot of cuttings. It was found that two portions of the cuttings would give the same percentage of residue to the nearest whole number, when the same procedure was used in their preparation.

All samples were thoroughly cleaned with water and dried on a gas plate. Various solvents, including carbon tetrachloride and ether, were tested in an attempt to remove the oil present in some of the residues, without satisfactory results. The difficulty is probably due largely to the nature of the petroliferous particles in the limestone which tend to flocculate when released by the acid, and do not dissolve.

After cleaning, the sample was examined under the low-power binocular microscope to determine its composition and mass characteristics. The Dundee and Detroit River formations are usually separated in exploration work by observation of the well cuttings in this manner, the "contact" being placed where there is a definite change from limestone to dolomite. Information obtained by a preliminary examination was found to be very helpful in the interpretation of the residue. After examination, the sample was passed through a 12-mesh sieve and accurately weighed.

The digestion of the soluble portion of the sample was the most important part of the procedure. For this reason several experiments were conducted to determine which solvent and concentration would give the best results. Both acetic and hydrochloric acids were tried. Because of the dolomitic character of much of the limestone encoun-

[7] W. L. Wilgus, Shell Petroleum Corporation, Wink, Texas, written communication.

tered in this investigation it was found that a 50 per cent solution of concentrated commercial hydrochloric acid would be most practical. Fifty cubic centimeters of acid was added to 50 cubic centimeters of water placed on the sample. Heat was applied to hasten the reaction where necessary.

The fine portion of the residue was saved at first but it was later found advisable to discard this part without weighing or examining. After decanting the fine portion, the remaining coarse portion was dried and weighed, then bottled and labeled in preparation for its examination. It was then observed under a binocular microscope with magnification up to 45×. Particular attention was paid to the mass characteristics of the residue, such as the presence of a large percentage of chert, dolocastic silt, detrital quartz, *et cetera*, rather than the presence of a grain or two of unusual minerals, which, though interesting in their occurrence, are of little aid in correlation. Minerals whose identity could not be determined under the binocular were removed from the residue and identified with the petrographic microscope.

After all the weights were recorded, calculations of the percentage residue were made. The relative amount of residue was indicated by vertical histograms of the residues for each well. At the base of each bar the percentages of the various components of the residues were indicated by means of different colors to represent minerals or aggregates, and their distinctive structures observed in the residues. Thus both quantitative and qualitative data were provided on the same sheet for the comparison of the residues. On completion of the logs, they were arranged side by side in order to note likenesses in amounts or composition of the residues. A series of such logs formed, in effect, a correlation chart.

GENERAL CHARACTERISTICS OF RESIDUES

Since the purpose of insoluble residue studies is to aid in correlation and in the interpretation of the history of the formations, it is necessary to observe and identify all minerals and structures which have been preserved. While insolubles, particularly the minor components, show many variations both horizontally and vertically, the mass characteristics as interpreted from the major components exhibit enough similarities horizontally, and vary enough vertically, to be an aid in the definition of lithologic units and in their correlation.

MAJOR COMPONENTS

Shale.—The most abundant of the components of the residues is shale. That found near the upper contact of the Dundee probably

represents cavings from the shales of the overlying Traverse formation, particularly the Bell shale member. There are generally two shales represented, the black carbonaceous shale characteristic of the Bell member, and gray shale characteristic of the overlying members. Lower in the section gray, black, and brown shales are found in varying quantities. Some blue-gray and gray-green shale was also observed. Laminated shale particles were found in some of the residues. The shale fragments range in size from microscopic to two or three centimenters in diameter, and range in shape from extremely angular to rounded or oval. Rounding of the shale fragments is largely due to attrition during the process of drilling. It was reproduced by the writer in the laboratory by shaking a mixture of small particles of shale, dolomite, and limestone in water. Because of their great vertical and horizontal range, shales were of little value in correlation, though their persistence in the Dundee and absence in the Detroit River were of some aid.

Silt.—Aggregates of silt were observed closely associated with shale and grading into it. In many instances this association was not observed and the particles formed a very distinct and characteristic assemblage. The aggregates are composed partly of very finely divided quartz and probably partly of clay minerals, but the fine division of the particles renders determination of the individual components very difficult. The aggregates are ordinarily brown-to-gray, have very porous structure, and many exhibit imprints of crinoid stem fragments and other fossils. They ordinarily show well developed dolocasts. Some aggregates, commonly within oil-bearing strata, are bituminous and black. Silt aggregates originate in the same manner as shales, but consist of slightly larger grains and are confined to more definite horizons. Apparently the carbonates were deposited among the grains before they were completely compacted so that porous structure is produced on removal of the soluble part.

Quartz sand.—Quartz sand is among the more important components of the insolubles and is of value when occurring in large amounts. Its presence in at least small percentages in practically all of the strata renders correlation by a few grains only, of little value. The particles generally range in size from one millimeter in diameter to extremely fine. Perfectly clear and well frosted grains ordinarily occur together. The frosted grains perhaps indicate aeolian transportation, but the relatively large size of some of them suggests that they were water-laid. The roundness of the particles was not measured, as it varies greatly even among the particles of a single residue. The particles are generally fairly well rounded, but range from grains showing their

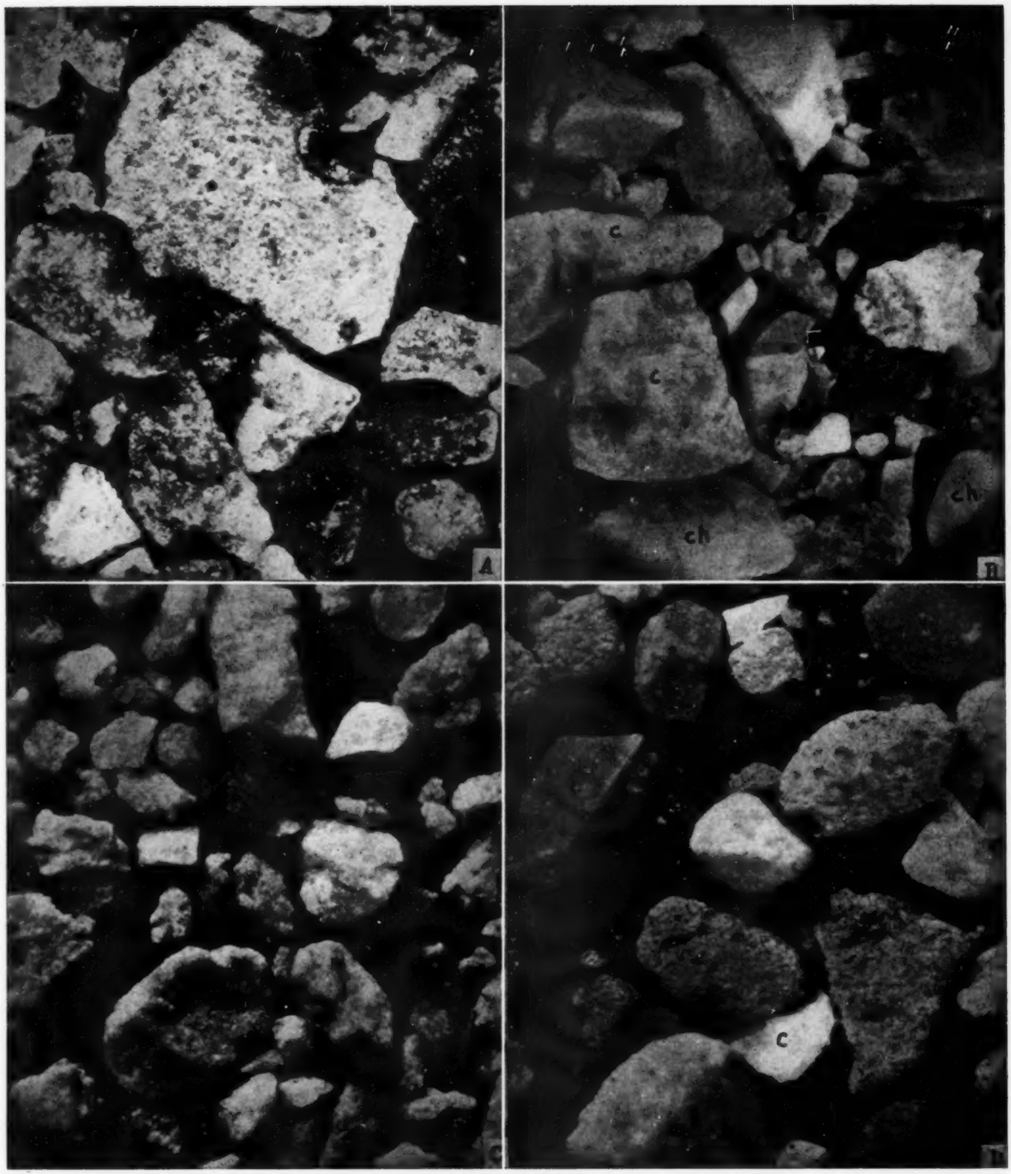

PLATE I

FIG. A.—Residue from well No. 2288. Middle Dundee residue composed of white-to-gray chert, which contains minute geodes, as in large fragment. Black substance of indeterminable composition separated geode from chert. ×25.

FIG. B.—Residue from well No. 154, consisting of white-to-brown chert (*c*), chalcedony (*ch*), and silt aggregates (*s*), showing development of dolocasts. Middle Dundee residue. ×32.

FIG. C.—Residue from well No. 2288, showing dolocasts in white, porous chert, with few grains of rounded and authigenic quartz. Middle Dundee. ×32.

FIG. D.—Residue from well No. 2553. Middle Dundee residue showing white and brown chert (*c*), and dark gray dolocastic aggregates. ×32.

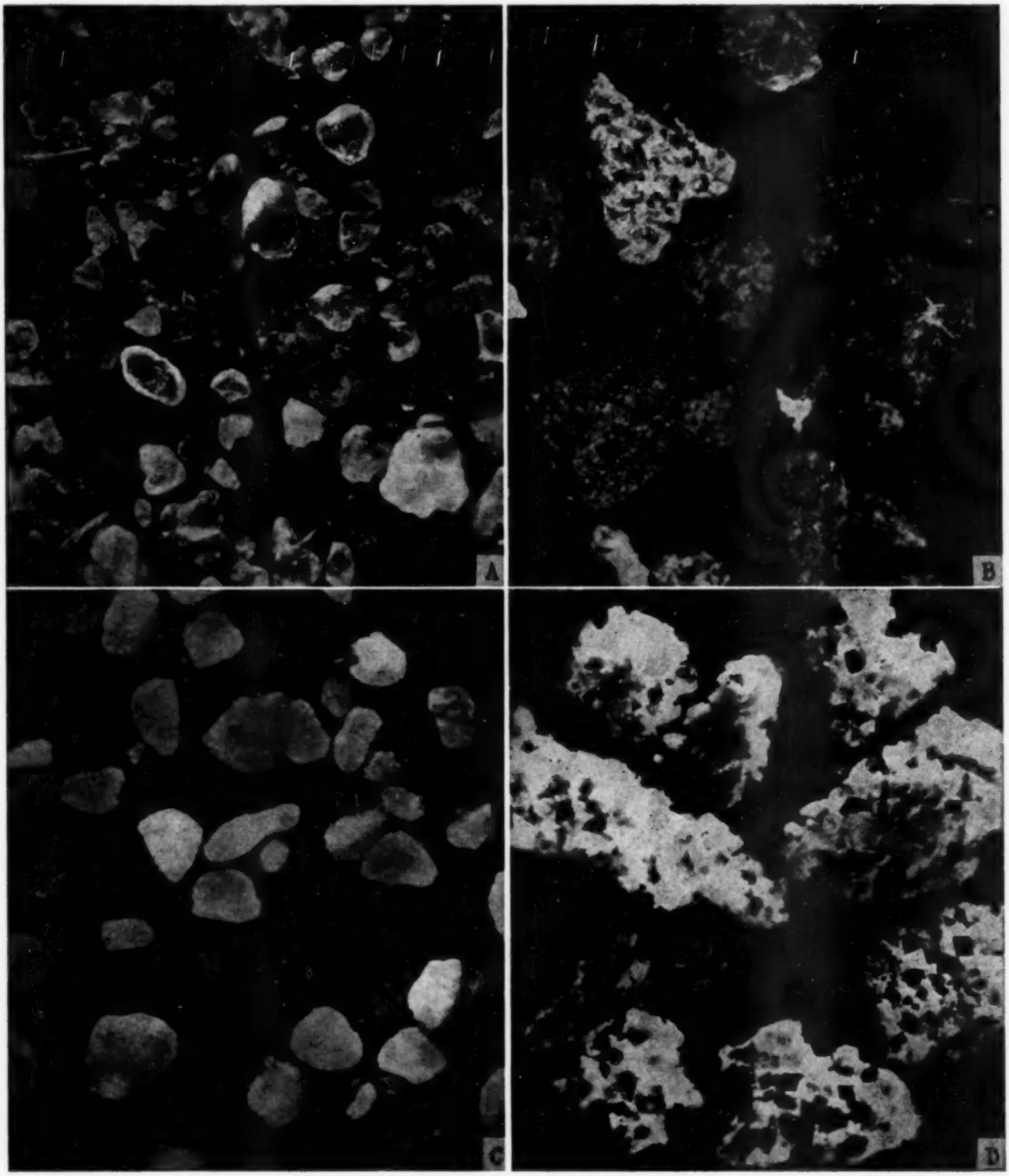

PLATE II

FIG. A.—Residue from well No. 2648, showing clear, subrounded quartz of upper Dundee. ×32.

FIG. B.—Residue from well No. 2573, showing gray-to-brown microcrystalline anhydrite with dolocasts of Detroit River. ×32.

FIG. C.—Residue from well No. 2200, showing white and brown anhydrite characteristic of Detroit River formation. ×32.

FIG. D.—Residue from well No. 400. Detroit River residue showing excellent development of dolocasts in chert. ×32.

original or secondarily formed crystal faces to grains approaching perfect spheres. A great variation in color of the grains was noted, but smoky, yellow, and reddish were most common.

Chert.—The cherts were found to be the best horizon markers in the Dundee formation and occur to a lesser extent in the Detroit River formation. Observed in the residues the chert was white, gray, bluish gray, brown, or black (flint) in color. The colors are rarely definite but grade from one to the other. Chert ordinarily occurs in fragments showing conchoidal fracture and fine cryptocrystalline texture as observed under the petrographic microscope. Some of the chert fragments examined have a "granular" appearance. Microscopic examination shows that they are also made up of cryptocrystals which are somewhat larger than in other varieties, and that individual crystals make up the "grains." This type of chert was also found to contain black specks which, on detailed examination, revealed a band of dark material of indeterminable composition inclosing a grain of crystalline quartz (Pl. I, Fig. A). The dark material was observed to cover the grain completely, and was also found inclosing minute quartz geodes. The cherts in many places are porous and form a very fragile skeleton which may show dolocasts.

Anhydrite.—Anhydrite is abundant in the insoluble residues, particularly those of the Detroit River formation where it is the most important constituent. It was found in many different forms, but in most places as (1) white and brown macrocrystalline, (2) white and brown massive microcrystalline, and (3) porous microcrystalline. The brown and white macrocrystalline forms are composed of fairly large elongate crystals exhibiting perfect pinacoidal cleavage in three directions, and a vitreous lustre. The coloring is probably due to the presence of small amounts of iron. The massive microcrystalline form is ordinarily pure white in color, but commonly exhibits a bluish tint and is also brown. It occurs in fairly large grains, the size being determined by the amount of fracturing produced in drilling. The action of water has apparently removed part of the anhydrite, making the material very porous. This porosity may be due in part or wholly to the solvent action of the hydrochloric acid in removing the anhydrite or the dolomite which it contained. Dolocasts have been observed in anhydrite, suggesting original deposition of the dolomite. The porous and dolocastic varieties vary from white microcrystalline to brown glassy anhydrite. Practically all of the anhydrite found was associated with dolomite.

Gypsum.—Gypsum makes up an important part of the residues and occurs in two forms: (1) colorless, vitreous crystals with perfect

pinacoidal cleavage, and (2) gray-to-white massive microcrystalline grains. It is present in both limestone and dolomite, but the massive variety is more common in the latter.

Authigenic quartz.—A large part of many of the residues is composed of authigenic quartz which is a poor indicator of stratigraphic horizons because of its usual erratic distribution. Martin,[8] however, has found crystalline quartz persisting in a vertical range of 30–40 feet in a distance of 100 miles in the Paint Creek formation of southern Kentucky. He believes that its deposition after lithification of the formation is unlikely. Small crystals of authigenic quartz have been observed in the present study. The form is ordinarily a hexagonal prism terminated by rhombohedrons. Their occurrence is extremely erratic and it seems most likely that their deposition is entirely secondary. Quartz grains made up of zones of clear and milky quartz are fairly common. In some grains the milky zones completely surround a core of clear quartz. Most of the grains are broken, having been shattered by the drilling process.

Pyrite.—Although in many places present in relatively large amounts, pyrite is of little value in correlation because of its secondary nature. It occurs at several horizons and in this study it was observed to occur above the sulphide or "black" water found at certain horizons within the Dundee and Detroit River formations. It is commonly found in a finely divided state, though many well developed cubes and pyritohedrons have been observed. Pyritized fossils were found in some of the residues.

Dolocasts.—Impressions of dolomite crystals in minerals or mineral aggregates are called dolocasts. They show the rhombohedral outline of the crystals of dolomite, and because in some places they occur within a narrow stratigraphic range, they are a valuable aid in correlation. The writer has observed dolocasts in shale, chert, and other varieties of silica, silt aggregates, and anhydrite. The size of the dolocasts differs considerably, even with the same material, and it is necessary to use high-power magnification in order to discern the smaller casts. Theories of the origin of the dolocasts depend to some extent on the accepted theory of the origin of the chert in which some of the dolocasts occur. If the cherts are syngenetic, it is likely the dolocasts were formed at the time of deposition or during lithification. The fact that the dolocasts occur also in shales and silt aggregates supports this view. Dolocasts were found in both limestone and dolomite and are possibly formed by the impressions of calcite as well as

[8] H. G. Martin, "The Insoluble Residues of Some Mississippian Limestones of Western Kentucky," *Kentucky Geol. Survey*, Ser. 6, Vol. 41 (1931), pp. 129–89.

dolomite crystals as suggested by Eddy.[9] However, the casts might have been formed by dolomite crystals contained in the limestone. There is room for further investigation of dolocasts, and an interpretation of their origin should shed new light on the theories of the origin of limestones and dolomites.

MINOR COMPONENTS

The cryptocrystalline mineral, chalcedony, occurs as wavy flaky fragments. It is fairly common, but is not persistent in the formations studied. The amorphous mineral, opal, was observed as composing very small parts of several Dundee residues. It occurs as small milky white fragments with conchoidal fracture. The feldspars recognized were microcline, orthoclase, and albite, and occurred as authigenic minerals in two residues observed.

The following minerals occurred in very minor amounts: fluorite, talc, titanite, biotite, muscovite, hematite, chlorite, amphibole, and limonite.

Large quantities of resin, lead, iron and steel, and limonite found in the residues, were apparently introduced artificially. Resin is formed from petroliferous samples by heating with hydrochloric acid in the process of preparing the residue. Lead is apparently derived from packing used in fitting joints at the well head. No means for the separation of the steel and iron introduced from the mineral magnetite (if present) was devised, and it is doubtful if such a separation would be of great value in this study. The writer believes that the magnetic material, which makes up a large percentage of some of the residues, is mostly steel. The limonite found in the residues is probably largely an alteration from steel particles, though some of it may have been derived from the magnetite and pyrite.

INSOLUBLE RESIDUES AND CORRELATION OF FORMATIONS

Because only well cuttings have been used in this study, the approach to insoluble residue analysis was necessarily two-fold. A set of insoluble residues of known stratigraphic horizon was necessarily established before units of unknown stratigraphic position could be correlated. Units which seemed most clearly to represent the Dundee and Detroit River as determined by lithologic studies of the cuttings from wells were chosen, and the residues of these units compared with those of other wells. Comparison of the wells was made in horizontal east-west and north-south sections, as shown on the accompanying map (Fig. 1). The sections as a whole were then compared.

[9] G. E. Eddy, *op. cit.*, p. 349.

Comparison of the residue well logs shows that the residues of the Dundee-Detroit River stratigraphic section of central Michigan are similar in exhibiting: (1) the occurrence of white-to-gray chert near the top of the Dundee; (2) an increase in the percentage of total residue in a zone 80–100 feet below the shale-"lime" contact, where it is composed largely of chert; (3) the presence of silt aggregates, which are dolocastic in many places, in the upper part of the Dundee; (4)

BELL		Gray to black shale.		
DUNDEE LIMESTONE	UPPER	Gray to black shale. White to gray chert, making up small percentage of total residue. Residue small.	Silt aggregates. Small dolocasts.	Detrital quartz, frosted and clear, erratically distributed. Authigenic quartz, milky and clear, erratically distributed. Consistent variation in percentage of residue.
	MIDDLE	White to gray chert, massive to porous, making up large percentage of residue. Residue large.		
	LOWER	Chert, usually gray, varying in relative amounts. Residue small.	Gypsum Pyrite	
DETROIT RIVER DOLOMITE		Anhydrite principal component. Shale, fine sand, and silt aggregates occur in small percentages of original sample, erratically distributed. Dolocasts large and well developed. Inconsistent variation in percentage of residue.		

FIG. 3.—Generalized columnar section showing residues characteristic of Dundee and Detroit River formations.

the variable amounts of detrital and authigenic quartz in the Dundee; (5) the erratic occurrence of fine detrital quartz in the Detroit River; (6) the lack of appreciable amounts of chert, shale, or sand, associated with the anhydrite in the Detroit River; (7) the excellent development of dolocasts in the Detroit River which are generally larger than those of the Dundee; (8) the consistent variation in the percentage of residue in the Dundee; and (9) the inconsistent variation in the percentage of residue in the Detroit River. A generalized section of the formations, showing residues characteristic of certain parts of the formations and of the formations as a whole is shown in Figure 3.

CONCLUSIONS

The supply of material for use in investigation of insoluble residues and application of the method to the formations of central Michigan is now practically unlimited, as new wells are constantly being drilled. The investigation of the few hundred samples discussed here is far from exhaustive, and it is hoped that these results will prove of value in stimulating further work along this line, both in observation of the residues and application of the method to the stratigraphic problems of this region.

The most important facts brought out in this investigation may be summarized as follows.

1. The insolubles from the Dundee and Detroit River formations of central Michigan contain certain constituents which in quantity and qualitative features are characteristic of each formation.

2. The insolubles from different parts of the Dundee formation show some differences so that the position of the sample in the section may be approximately determined.

3. The fine portion of the residue is of little value in correlation because of its inconsistent vertical and horizontal distribution.

4. Quantitative measurement of the coarse residue is of value in correlation when complete sections may be compared, and when anhydrite and shale are not present in large amounts.

5. The characteristics and the relative percentage of the constituents of a residue afford the most salient criteria in correlation by this method, especially when complete stratigraphic sections may be compared.

6. The residues provide no direct evidence of the presence or absence of an unconformity between the Dundee and Detroit River.

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BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
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GRAVITY IN SOUTHEASTERN VIRGINIA[1]

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ABSTRACT

During the summer of 1936, the United States Coast and Geodetic Survey made gravity determinations at 16 stations in Virginia along practically a straight line from the vicinity of Petersburg to the coast southeast of Norfolk. The work was requested by Professors Miller and Ewing of Lehigh University and follows closely a line of seismic determinations made by the latter. The results were reduced by the isostatic method and a profile of isostatic anomalies was thus obtained. The observed values of gravity and other essential data for the stations are given in a table and the results are discussed briefly. The gradual downward slope of the gravity profile toward the east corresponds approximately with the slope of the basement rocks but is somewhat steeper than would be expected from this cause alone unless a very low density is assumed for the overlying material.

The tendency for the intensity of gravity to be less than normal along the coasts of the United States is well known. A logical explanation is that set forth by Hayford and Bowie in 1912,[3] namely, that the coastal plains are underlain to a considerable depth by sedimentary material, the density of which is appreciably less than that of average surface rock.

An interesting study of gravity variations in the vicinity of the Atlantic Coast in Virginia was made during the summer of 1936 by the Coast and Geodetic Survey. Sixteen gravity determinations were made along nearly a straight line from a point southwest of Richmond to one on the Atlantic Coast a few miles southeast of Norfolk. The work was requested by Benjamin L. Miller and Maurice Ewing of Lehigh University and the locations of the stations were selected by them to follow closely the line of seismic observations made by Ewing under the sponsorship of the committee on the geophysical and geological study of oceanic basins of the American Geophysical Union. The gravity stations, however, are not identical with the seismic stations.

The gravity observations were made with the Brown type of gravity apparatus developed a few years ago by the Coast and Geodet-

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[3] John F. Hayford and William Bowie, *U. S. Coast and Geodetic Survey Spec. Pub. 10*, pp. 113–17.
See also William Bowie, *ibid.*, *Spec. Pubs. 12*, *40*, and *99* for more extensive discussions of this relationship between isostatic anomalies and geological formations.

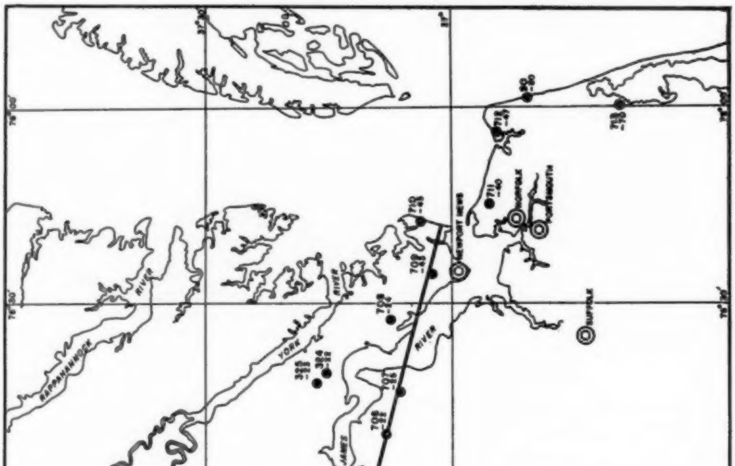

FIG. 1.—Locations of gravity stations. For each station are shown its number and its isostatic anomaly based on International formula. Heavy line shows position of profile of Figure 2.

ic Survey. This apparatus employs a half-second pendulum of invar alloy, the timing of which is accurately determined by means of automatic comparisons between its oscillations and the radio time signals of the Naval Observatory as transmitted by the Naval Communications Service. In order to insure the integrity of the results in Virginia, two sets of the Brown apparatus were used simultaneously at each station, thus giving two determinations of gravity entirely independent of each other except as they were affected by possible small errors in the time signals. The observed values are probably accurate within one or two milligals.

The locations of the stations are shown in Figure 1. Previously determined stations at Richmond, Emporia, Williamsburg, and Virginia Beach are also shown. The one at Virginia Beach is so nearly in line with the new stations that it has been considered with them in the present discussion. The average spacing of the new stations (including No. 90) is 8 miles, varying from a maximum of 14 miles between Nos. 698 and 699 to a minimum of 4½ miles between Nos. 702 and 703. For the general gravity surveys carried on by the Coast and Geodetic Survey, this spacing is considered as constituting a fairly intensive survey.

The data for the stations are given in Table I. They include for each station, its latitude, longitude, and elevation, the observed value of gravity, the theoretical value of gravity at sea-level for the latitude of the station as derived by the use of the International formula, corrections for elevation and for topography and isostatic compensation, and finally the free-air and isostatic anomalies. The isostatic anomalies are shown also in Figure 1. The anomalies are the differences between the actual observed values of gravity and the computed values. To obtain the free-air anomalies, the theoretical value of gravity at sea-level for the latitude of the station was corrected to take account merely of the elevation of the station and was then subtracted from the observed value to give the anomaly. To obtain the isostatic anomalies two additional corrections were applied, one to take account of the positive effect of all visible topography and the negative effect of oceanic basins and the other to take account of the isostatic compensation of that topography in the underlying so-called crust of the earth extending down to the limiting depth of 113.7 kilometers.

It has been found from the study of numerous gravity stations in many parts of the world that if the geological formations underlying a station have approximately the average specific gravity of the surficial part of the whole earth then the isostatic anomaly is likely to be

TABLE I
DATA FOR GRAVITY STATIONS

Number and Name of Station	Latitude		Longitude		Elevation in Meters	Observed Gravity in Gals	Theoretical Gravity at Sea-Level in Gals	Correction		Anomaly	
	Deg.	Min.	Deg.	Min.				Elevation in Gals	Topography and Compensation in Gals	Free Air in Gals	Isostatic in Gals
90 Virginia Beach	36	50.5	75	58.4	4	979.877	979.903	−0.001	+0.025	−0.025	−0.050
146 Richmond	37	32.2	77	26.1	30	979.965	979.964	− .009	+ .010	+ .010	.000
147 Emporia	36	40.2	77	31.0	37	979.903	979.888	− .011	+ .015	+ .026	+ .011
324 Williamsburg	37	15.6	76	40.8	26	979.927	979.940	− .008	+ .017	− .005	− .022
325 William and Mary	37	16.3	76	42.6	30	979.926	979.941	− .009	+ .017	− .006	− .023
698 Amelia	37	21.1	77	58.2	111	979.947	979.948	− .034	+ .012	+ .033	+ .021
699 Winterpock	37	20.5	77	43.1	66	979.949	979.947	− .020	+ .010	+ .022	+ .012
700 Ettrick	37	15.2	77	25.5	33	979.920	979.939	− .010	+ .010	− .009	− .019
701 Leader	37	16.8	77	34.0	93	979.914	979.941	− .029	+ .015	+ .002	− .013
702 Prince George	37	13.6	77	16.4	42	979.939	979.937	− .013	+ .013	+ .015	+ .002
703 Cadillac	37	11.4	77	12.6	38	979.947	979.933	− .012	+ .014	+ .026	+ .012
704 SW. of Burrowsville	37	11.1	77	06.2	20	979.943	979.933	− .006	+ .013	+ .016	+ .003
705 Spring Grove	37	10.0	76	58.6	33	979.925	979.931	− .010	+ .015	+ .004	− .011
706 Surry	37	08.0	76	50.0	39	979.912	979.929	− .012	+ .017	− .005	− .022
707 Bacon's Castle	37	06.4	76	43.8	25	979.910	979.926	− .008	+ .017	− .008	− .025
708 Warwick	37	07.6	76	32.8	10	979.919	979.928	− .003	+ .018	− .006	− .024
709 Little Bethel	37	02.5	76	25.8	6	979.895	979.921	− .002	+ .019	− .024	− .043
710 E. of Blacksome's corner	37	03.6	76	17.6	3	979.896	979.922	− .001	+ .020	− .025	− .045
711 Oakwood	37	55.7	76	14.6	4	979.892	979.911	− .001	+ .022	− .018	− .040
712 Lynn Haven	36	54.8	76	03.6	2	979.885	979.909	− .001	+ .024	− .023	− .047
713 Chanty Neck	36	39.6	75	59.2	0	979.845	979.888	.000	+ .027	− .043	− .070
Means with regard to sign										− .002	− .019
Means without regard to sign										.017	.025

near zero. In other words, if the isostatic method is used, it is possible to predict the value of gravity at any place with rather high accuracy except as the value is affected by departures from normal density in the rock immediately surrounding the station.

This conclusion is borne out by the results at the stations under discussion. Geological maps of this area show that the top of the basement rocks slopes downward toward the coast. The overlying sedimentary rocks have a density appreciably less than that of average surface rock which in the isostatic reductions is taken as 2.67. The gravity gradient also slopes downward toward the coast and therefore corresponds with the geology. It is apparently too steep, however, to be explained as due only to deficiency of density in the sedimentary rocks which begin near Petersburg (near station No. 700) and increase in thickness toward the coast.

A well boring at Old Point Comfort shows that the depth to crystalline rock at that point is about 2,250 feet. It we assume an average density of 2.0 for a layer of rock 2,250 feet thick the effect of the deficiency of density in this layer amounts to about 19 milligals or less than one-half the isostatic anomaly found near Old Point Comfort.[4]

A casual study of the anomalies might seem to show that they give an indication of the attraction of the Appalachian Mountains and of the negative effect of the deep parts of the Atlantic Ocean. It must be remembered, however, that the isostatic reduction eliminates these effects from the anomalies. It should also be noted that the free-air anomalies show a gradient slightly less than the isostatic anomalies even though no corrections have been applied for the topographic effect. Apparently therefore the near-by topography is more than offset by the effects of the isostatic compensation and the distant topography.

Too much importance should not be given to the absolute size of the anomalies, as the datum may be changed several milligals by use of a different gravity formula. The anomalies in the table are based on the International formula, this formula having been used in comput ing the theoretical values of gravity at sea-level for the various stations. If the Bowie formula of 1917 had been used, the anomalies would have been about 9 milligals greater algebraically, and the negative anomalies near the coast would have been about 9 milligals

[4] R. T. Chamberlin has called the writer's attention to the possible effect of the light muds and unconsolidated sediments in Chesapeake Bay and in the adjacent parts of the Atlantic Ocean. Undoubtedly these do have an appreciable effect on the anomalies at the Virginia stations, especially at those near the coast. No attempt has been made to evaluate these effects in the isostatic reductions as definite information is lacking regarding the sizes and densities of the masses involved.

less numerically. Relatively to each other, however, the anomalies are practically the same on either basis. The two formulas mentioned are as follows.

International[5].—

$$\gamma_0 = 978.049\ (1 + 0.0052884\ \sin^2 \phi - 0.0000059\ \sin^2 2\ \phi)$$

Bowie[6].—

$$\gamma_0 = 978.039\ (1 + 0.005294\ \sin^2 \phi - 0.000007\ \sin^2 2\ \phi)$$

In Figure 2 the anomalies are shown as profiles. The line of the profile is shown as *AA* on Figure 1. It practically coincides with the seismic profile determined by Ewing. In order to make the profile

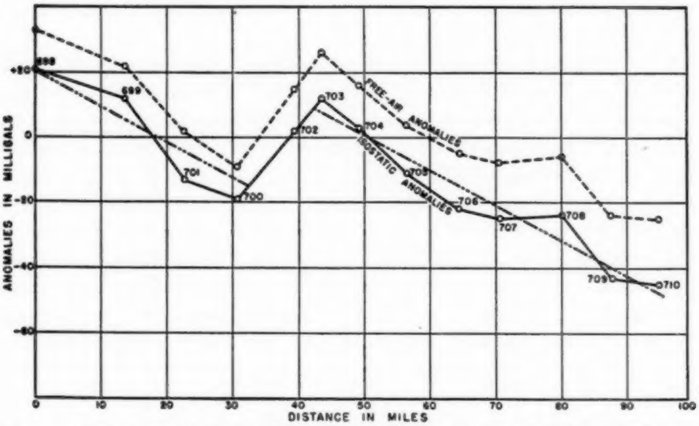

FIG. 2.—Gravity gradients as indicated by isostatic and free-air anomalies. Position of profile is shown on Figure 1.

follow a straight line it was necessary to project several of the stations onto the line by offsets at right angles to it. Most of these offsets are small and probably do not materially affect the anomalies. The offsets at stations 708 and 710 are rather large. In the case of station 708, the anomaly may be several milligals different at the projected point. The break in the profile at this station, therefore, may be partly due to this offset. In the case of station 710, however, the surrounding stations have anomalies so nearly the same size that the offset probably has little effect.

The free-air profile of Figure 2 is very similar to the isostatic pro-

[5] G. Cassinis, *Bull. Géodésique 32*, p. 314.

[6] William Bowie, *U. S. Coast and Geodetic Survey Spec. Pub. 40*, p. 134.

file and nearly parallel with it. This is to be expected in a fairly flat area such as this since the correction for topography and isostatic compensation varies rather slowly from station to station.

The two most noticeable characteristics about the isostatic profile are first its downward slope toward the coast and second the very pronounced break between stations 700 and 703. The two parts of the profile on either side of the break are nearly parallel, as indicated by the parallel dash-and-dot lines. The surface geology in the vicinity of the three stations where the break occurs apparently gives no indication of a large difference in density occurring here. Is there a reasonable possibility of a buried structural feature such as a fault near station 702, parallel with the coast, of sufficient magnitude to cause this striking change in the gravity gradient? This is a logical explanation if it is not contrary to the known geology of the region.

Many additional stations are needed to give a clear picture of the gravity field along this part of the coast. At least two more profiles perpendicular to the coast and one or more parallel with it, requiring 75–100 stations, are obviously desirable. Requests have already been received by the Survey for such additional determinations and it is hoped that the work may be done in the near future. If possible, the project should be made to include an extension of one or more of the profiles northwestward across the Appalachian Mountains.

It seemed desirable to present the data for the gravity stations discussed in this paper because of the great interest in the results shown by geologists and geophysicists. Ewing, who made the seismological observations and measurements along the route followed by the gravity survey, will discuss the relation of the gravity results to his seismic results in the near future. The writer has purposely avoided any discussion of the results obtained by Ewing in his seismic work.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 21, NO. 3 (MARCH, 1937), PP. 340-351, 4 FIGS.

SOME DIP PROBLEMS[1]

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ABSTRACT

After brief remarks on the history of the solution of dip problems, there is described a simplified chart for the determination of the components of gentle dips. There follows a short discussion of the slope scale and the "minimum scale-error graph." The latter is a slope scale carrying an extra series of figures showing the percentages that must be added to scaled distances between points of different altitudes on large-scale contour maps to give minimum actual distances. Lastly are recounted two of Harker's examples one of which in particular, the problem of two tilts, is thought to merit more attention than it has received.

In a recent number of this *Bulletin*[3] John L. Rich gives credit to G. D. Harris for publishing a method described by Rich[4] 4 years ago. It seems to the writer that credit for the original demonstration should go back at least as far as Penning[5] of the British Survey, though the Reverend Hill[6] (the title indicates how old this idea is) pointed out a modification of Penning's solution necessary to make it accurate for all but small angles. The writer has no doubt that Professor Harris did an original job; the writer repeated it in 1925 shortly after he first started to teach crystallography by means of the gnomonic projection. At the time the writer prepared a paper for publication, but withheld it on discovering an article by Harker[7] citing the earlier literature. It is surprising that Rich did not realize that Harker or his predecessors deserved the credit since he cited a note[8] by one of the present writer's former students to whom had been emphasized in class room the value of Harker's work and which was in essence a rehash of part of Harker's article. An explanation

[1] Manuscript received, December 31, 1936.

[2] University of Chicago.

[3] John L. Rich, "Graphic Method for Determining True Dip from Two Components," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 11 (November, 1936), p. 1496.

[4] John L. Rich, "Simple Graphical Method for Determining True Dip from Two Components and Constructing Contoured Structural Maps from Dip Observations," *ibid.*, Vol. 16, No. 1 (January, 1932), pp. 92–94.

[5] W.H. Penning, "Apparent and True Dip," *Geological Magazine*, Vol. 3 (2), 1876, pp. 236–37.

[6] E. Hill, *ibid.*, p. 334.

[7] A. Harker, "Graphical Methods in Field Geology," *Geological Magazine*, Vol. 1 (3), 1884, pp. 154–62.

[8] M. King Hubbert, "Graphic Solution of Strike and Dip from Two Angular Components," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 3 (March, 1931), pp. 283–86.

possibly lies in the fact that Rich plots cotangents whereas Harker[9] preferred tangents.

The fundamental formula is

$$\tan A = \tan T \cos H \qquad (1)$$

which may be written as

$$\cot T = \cot A \cos H \qquad (2)$$

or in several other ways (e.g., $\tan T = \tan A \sec H$)

where T = vertical angle of true dip

A = vertical angle of apparent dip in any given direction

and H = horizontal (compass) angle between the given direction of apparent dip and the direction[10] of true dip.

This formula was used at least as far back as 1859 (before the Civil War!) by J. B. Jukes[11] to prepare angle tables giving corrections for dip in directions not perpendicular to the strike, such as those copied by Lahee.[12] To avoid the errors almost certain to creep into such a table (there are several in Lahee), the writer prefers to use a graph of this formula such as that given by Wright[13] or by Palmer.[14] However, if dips are gentle, it is possible to multiply the true dip by cos H to get the apparent dip in any required direction.

That is,

$$A = T \cos H \qquad (3)$$

This may be derived from equation 1 if it be remembered that the tangents of small angles are directly proportional to the angles themselves.

It is thus possible to prepare a simple straight-line graph to solve apparent versus true-dip problems for small angles as is shown in

[9] In the article cited, see reference listed in footnote 8, p. 286, Fig. 3.

[10] If strike direction be preferred to true dip direction, H of formulas 1 and 2 becomes 90-H; thus cos H is replaced by sin 90-H.

[11] J. B. Jukes, *Geology of the South Staffordshire Coalfield*. Memoir of the Geological Survey of Great Britain (2nd ed., 1859), p. 215 (appendix).

[12] F. H. Lahee, *Field Geology* (3d ed., 1931), p. 724. Also see Willis and Willis, *Geologic Structures* (3d ed., 1934), pp. 453–54.

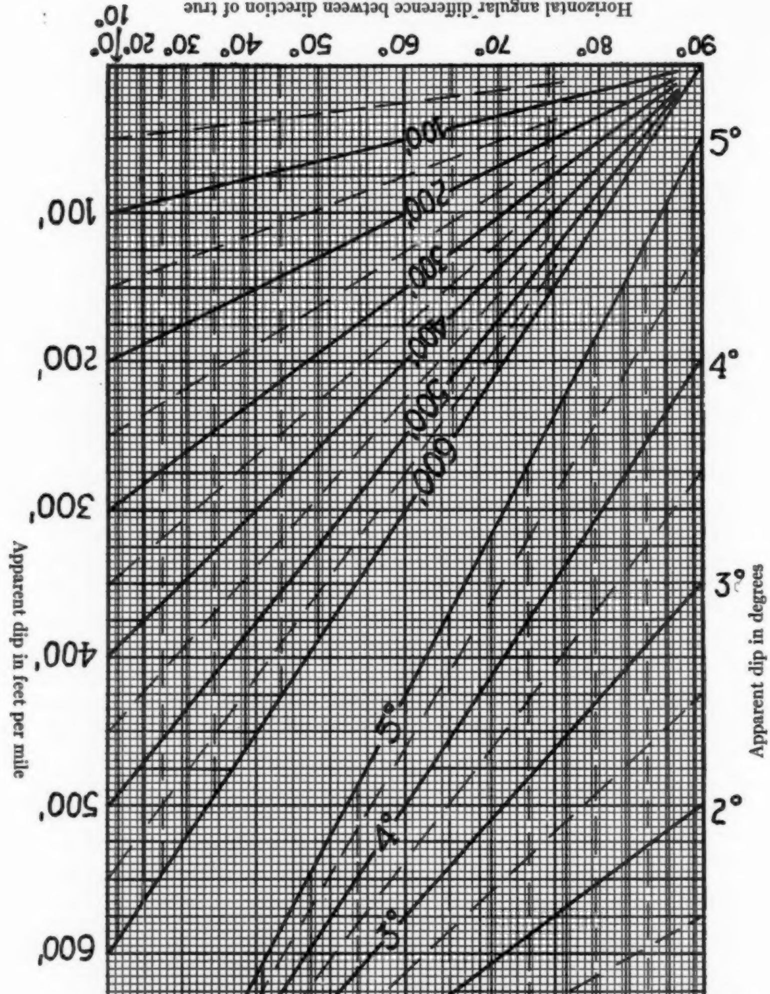
[13] F. E. Wright, "A New Dip Chart," *Jour. Washington Acad. Sci.*, Vol. 4 (1914), pp. 440–44. This is a straight-line network and therefore to be preferred to the set of curves given by D. F. Hewett in *Econ. Geol.*, Vol. 7 (1912), pp. 190–91, though the latter has been reproduced by Greenly and Williams, *Methods in Geological Surveying* (1930), Fig. 63. F. E. Wright, in *Jour. Washington Acad. Sci.*, Vol. 6 (1916), p. 5, says W. G. Woolnough first described such a chart in 1909.

[14] H. S. Palmer, "New Graphic Method for Determining the Depth and Thickness of Strata and the Projection of Dip," *U. S. Geol. Survey Prof. Paper 120* (1918), Pl. 16.

C. H. Johnson (*Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 6, June, 1936, pp. 816–18) has published an alignment chart essentially the same as Palmer's.

Horizontal angular difference between direction of true dip and direction of apparent dip

FIG. 1B.—The inclined lines indicate the values of true dip in feet per mile.



Horizontal angular difference between direction of true dip and direction of apparent dip

FIG. 1A.—The inclined lines indicate the values of true dip in degrees.

FIG. 1.—Network to solve dip problems involving small dip angles.

Figure 1 in which the abscissa values are plotted as cosines of the horizontal angle H. This differs from Wright's chart[15] in that (1) it is limited to small angles, (2) the ordinate values are drawn on a larger scale and so more accurate readings can be obtained, (3) equal ordinate values are represented by equal distances, and (4) results may be read in terms of feet per mile as well as in degrees.

TABLE I

True Dip (T°)	Horizontal Angle (H°)	*Apparent Dip (A)* By Formulas 1 or 2		By Formula 3		Difference	
		Degrees	Minutes	Degrees	Minutes	Degrees	Minutes
1	20		56.38		56.38		0.00
	60		30.00		30.00		0.00
3	20	2	49.17	2	49.15		0.02
	60	1	30.06	1	30.00		0.06
5	10	4	55.46	4	55.44		0.02
	25	4	32.02	4	31.89		0.13
	40	3	50.05	3	49.80		0.25
	45	3	32.40	3	32.13		0.27
	50	3	13.12	3	12.84		0.28
	55	2	52.36	2	51.08		0.28
	60	2	30.28	2	30.00		0.28
	65	2	7.05	2	6.78		0.27
	70	1	42.83	1	42.60		0.23
	80	0	52.22	0	52.08		0.14
10	20	9	24.49	9	23.72		0.77
	60	5	2.30	5	0.00		2.30
15	10	14	46.92	14	46.32		0.60
	20	14	7.96	14	5.73		2.23
	45	10	43.73	10	36.39		7.34
	60	7	37.84	7	30.00		7.84
	75	3	58.03	3	52.92		5.11
20	20	18	52.93	18	47.64		5.29
	60	10	18.85	10	0.00		18.85
25	20	23	39.74	23	29.55		10.19
	60	13	7.46	12	30.00		37.46
30	20	28	28.90	28	11.46		17.44
	60	16	6.13	15	0.00	1	6.13
50	20	48	14.23	46	59.10	1	15.13
	60	30	47.39	25	0.00	5	47.39

Examples of the use of Figure 1.—Given: true dip = 3° to N. 40° W. *Problem 1:* what is the apparent dip to N. 20° E.? Here the difference in the two directions is 60°, the horizontal angle H. From the

[15] F. E. Wright, *op. cit.*

base of Figure 1A go up along the 60° vertical line until the 3° true-dip line (inclined) is cut. From this point go horizontally to the right and read 1° 30′, the answer. *Given:* true dip = 250 feet per mile in a direction S. 25° E. *Problem 2:* what is the apparent dip to S. 70° E.? Here the horizontal angular difference is 45°. From the base of Figure 1B go vertically up along the 45° dashed line until the 250′ true-dip line (inclined, dashed) is cut. From this point go horizontally to the right and read 177 feet per mile, the answer. Figure 1B is also suitable for working such problems when the dip is expressed as a grade (in per cent). In this case the two 100′ symbols are taken to read 1 per cent, *et cetera.*

As before stated, the graphs of Figure 1 are based on a formula which is true only for small angles. The errors as obtained by this method compared with the rigorously true results given by formulas 1 or 2 are brought out in Table I.

It will be noted that when formula 3 is used for angles up to 10° the error may be as great as 2½ *minutes*, and for angles of 15° the maximum error is less than 8 minutes. It thus seems probable that Figure 1 could be used to advantage for angles up to 15° or so (by multiplying all figures by 2 or by 3 where necessary), beyond which value Wright's graph would be more accurate.

Rich's earlier article[16] also makes use of the slope scale, though that name is not applied. Rich notes that the idea is not original, but does not know its source. Neither does the writer; but one was described and figured in 1882,[17] and slope scales were probably used by both civil and military topographers some years earlier. To make a slope scale

> multiply the natural cotangents of angles of integral degrees by the contour interval used and plot the values thus obtained in feet (or the unit in which the contour interval is measured) at the mapping scale. The slope scale is simply a graphic representation to show the spacing of the contours for preparing a map of a slope of any given angle on a definite horizontal scale at a certain contour interval. Such a scale is often handy for drawing structure contours where the dip and strike are known, too, or for reading the angle of dip from a structure contour map.[18]

[16] John L. Rich, *op. cit.*

[17] E. Hergesheimer, "A Treatise on the Plane-Table and Its Use in Topographical Surveying," *U. S. Coast and Geodetic Survey Rept. for 1880*, Appendix 13, p. 189 and Fig. 46 (called "Scale of Hill Curves"). It should perhaps be noted here that Harker (*op. cit.*, p. 157) clearly brings out the idea of the utilization of vectors to represent amount and direction of dip. But since the tangent relationship is developed, Harker really makes use of the equivalent of a reciprocal slope scale.

[18] D. Jerome Fisher, *Syllabus for Planetable Mapping.* University of Chicago Bookstore (2d ed., 1935), p. 22.

Busk[19] has devised an interesting modification of the slope scale which he uses for checking formation thicknesses in the field. Finch,[20] who gives an excellent description of the slope scale, notes that it is common to have these at the bottom of the United States Army War Game maps; here they are called *M. D.* (map distance) scales. Bryant and Hughes[21] state that "of all published maps those of Greece are unique in having a scale of slopes shown on each sheet." Dwerryhouse[22] refers to it as "a scale of horizontal equivalents."

A modification of the slope scale serving the additional purpose of showing the scale error on contour maps, which may be called the "minimum scale-error graph," may be of value. Every educated adult knows that the distance between two points not at the same altitude scaled from an ordinary (large scale) map is less than the "straight-line" walking distance, because maps are projections on to a plane. If the ground surface is a uniformly inclined slope, with dip of $d°$, then the true distance, *T. D.*, between two points is related to the distance scaled from the map, *M. D.*, as shown in 4:

$$T.\ D.\ \cos d = M.\ D. \tag{4}$$

This combined with the slope scale formula leads to the equation

$$\frac{100}{\cos d} - 100 = Z \tag{5}$$

where Z is the percentage of minimum scale error. Solving equation 5 for various values of d gives the results shown in Table II.

TABLE II

d	*Z*	*d*	*Z*	*d*	*Z*
1°	.016%	13°	2.631%	25°	10.336%
2	.060	14	3.062	26	11.260
3	.139	15	3.529	27	12.233
4	.244	16	4.031	28	13.258
5	.384	17	4.568	29	14.334
6	.550	18	5.145	30	15.470
7	.751	19	5.762	31	16.662
8	.984	20	6.417	32	17.919
9	1.247	21	7.115	33	19.236
10	1.543	22	7.853	34	20.622
11	1.871	23	8.635	35	22.078
12	2.235	24	9.464	36	23.606

If the lines on the slope scale are thus marked not only with degrees of dip of the surface, but also with the figures given in Table II, the result is a minimum scale-error graph.

[19] H. G. Busk, *Earth Flexures* (1929), pp. 65–66.

[20] J. K. Finch, *Topographic Maps and Sketch Mapping* (1920), p. 59.

[21] *Map Work* (1918), p. 71.

[22] *Geological and Topographical Maps* (1911), p. 9.

Example of use of the minimum scale-error graph.—Given: the distance between two points on a contour map as 9,000 feet according to the map scale. Suppose for the first third of the distance the contour-spacing is such that the average surface dip is 8°, as shown by a slope scale prepared for use on the map in question. For the remaining two-thirds of the distance the average surface dip may be taken as 15°. The minimum surface distance between the two points is then

$$3{,}000+(.984\% \text{ of } 3{,}000)+6{,}000+(3.529\% \text{ of } 6{,}000)=9{,}241 \text{ feet.}$$

How much the true "straight-line" walking distance between the two points in question exceeds 9,241 feet depends on the amount of roll or undulation possessed by the surface.

It is also possible to solve such problems avoiding the multiplications necessary in taking percentages by simple graphical means, using a chart such as that shown in Figure 2. Here the scaled map distances are given along the abscissa and these plus the minimum necessary additions because of an inclined terrain appear on the ordinate. The sloping lines extend from the zero-zero apex to points spaced along the minimum slope distance 1,000-line in cosine ratios. Thus the 60° "surface-dip" (inclined) line of Figure 2 cuts the 1,000-line at a "map distance" of 500 (cos 60°=.500), the 30° line cuts at 866, *et cetera*. The surface-dip lines of Figure 2 are given for all values above 5° by 5° intervals. In actual practice dips less than 5° can be ignored and dips less than 8° are of very minor importance in this connection unless considerable distances are involved.

Examples of the use of Figure 2.—Given: a scaled map distance of 8,500 feet with a surface dip of 35°. From the 850 point on the abscissa go vertically up till the 35° inclined line is cut at a point from which by going horizontally to the left one reads 1,040 on the ordinate scale. The minimum slope distance is thus 10,400 feet (10,370 if computed from the data of Table II). *Given:* scaled map distance of 4.55 miles with surface dip of 25°. From the $2\times4.55=9.10$ point on the abscissa go up to the 25° inclined line and follow to the left, reading 1,008. The minimum slope distance is thus ½ of 10.08 or 5.04 miles. From the data of Table II this is computed as 5.02 miles.

It is the writer's opinion that if slope scales with minimum scale-error graphs were added to topographic maps, and if simple descriptions of these were printed as a part of the general explanation of the maps, the outdoor-loving public, always eager to know the true distances of hikes, would take increased interest in the contour lines. Such graphs should be of interest to the engineer making preliminary estimates of the amounts of material needed for laying pipe lines or building highways.

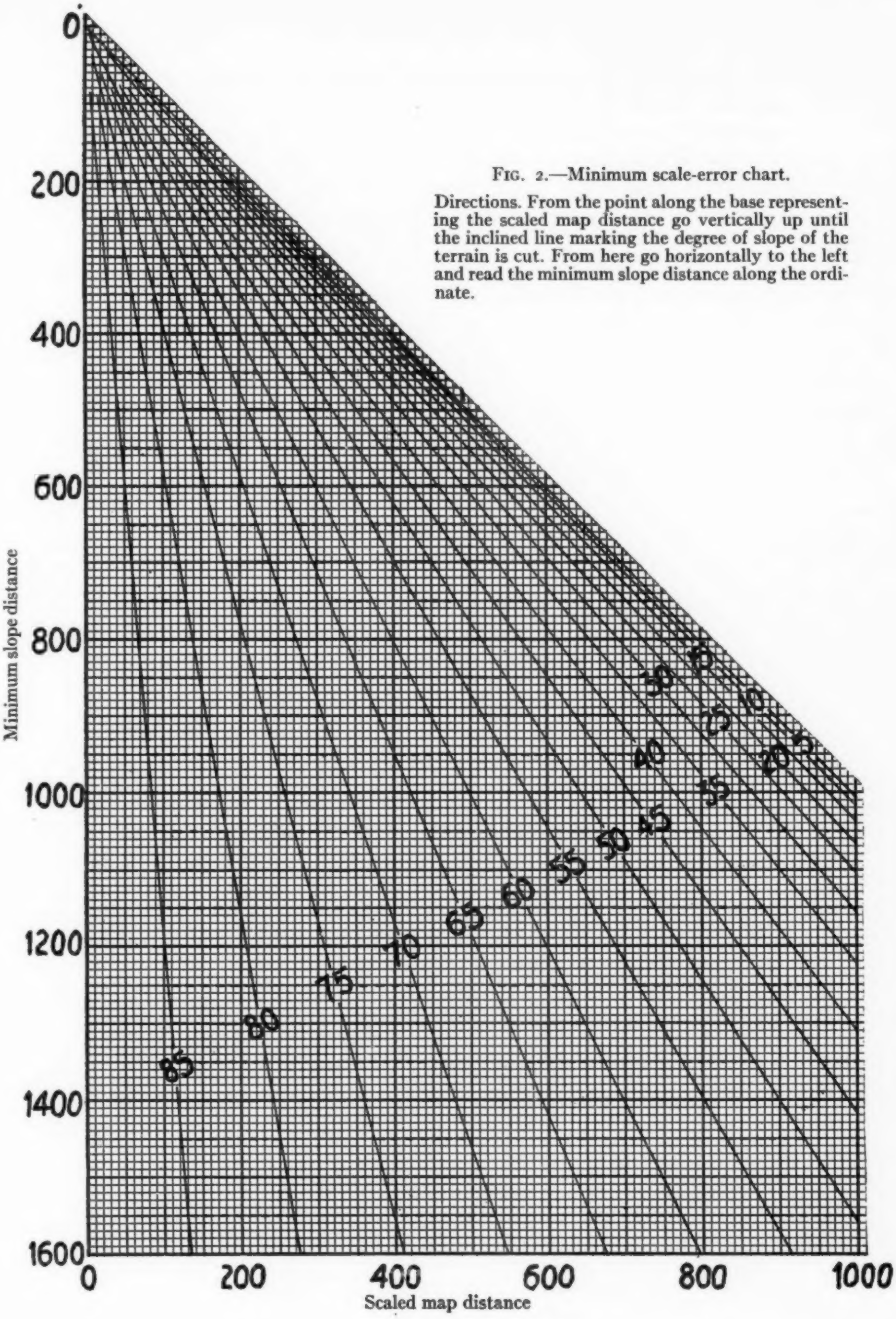


FIG. 2.—Minimum scale-error chart.

Directions. From the point along the base representing the scaled map distance go vertically up until the inclined line marking the degree of slope of the terrain is cut. From here go horizontally to the left and read the minimum slope distance along the ordinate.

Although the methods described by Harker are old, they appear to be little known in this country,[23] and yet the writer regards them as superior to anything since developed for certain purposes. Accordingly, for the benefit of those who receive this *Bulletin*, the following two problems are included. They do not duplicate the two already published,[24] but do cover all types of the remaining eleven problems listed in 1884 by Harker except those involving ground slopes, which latter can rarely be satisfactorily regarded as planes unless one is dealing with determinations of thickness of formations.

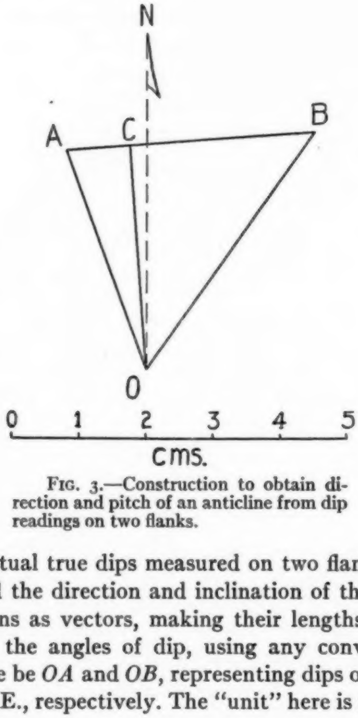


FIG. 3.—Construction to obtain direction and pitch of an anticline from dip readings on two flanks.

Given: the actual true dips measured on two flanks of a plunging anticline; to find the direction and inclination of the axis.[25] Plot the two dip directions as vectors, making their lengths proportional to the tangents of the angles of dip, using any convenient scale. In Figure 3 let these be *OA* and *OB*, representing dips of 4° to N. 20° W. and 5° to N. 35° E., respectively. The "unit" here is taken as 50 cms.;

[23] They are described at least in part in several English works.
A. R. Dwerryhouse, *Geological and Topographical Maps* (1911), pp. 110–12.
A. Harker, *Notes on Geological Map Reading* (1920), not seen.
G. Elles, *The Study of Geological Maps* (1921), pp. 32–36, 46, 51, 65.
K. W. Earle, *Dip and Strike Problems* (1934), pp. 115–17.

[24] M. King Hubbert, *op. cit.*

[25] This problem was solved trigonometrically for anticlines and synclines by F. W. Hutton as early as 1874, *Geological Magazine*, Vol. 1 (2), p. 44.

thus, $OA = 50$ cms. $\times$ tan $4° = 3.50$ cms. and $OB = 50$ cms. $\times$ tan $5° = 4.37$ cms. Draw AB and from O drop a perpendicular to AB cutting it at C. Then OC points in the required direction, N. 4° 20′ W. in this case, and the distance $OC(= 3.37$ cms.) corresponds with a dip of 3° 51′ (tan 3° 51′ $\times$ 50 cms. $= 3.37$ cms.). The construction is identical with that of Figure 1 of Rich,[26] except tangents are plotted instead of cotangents.

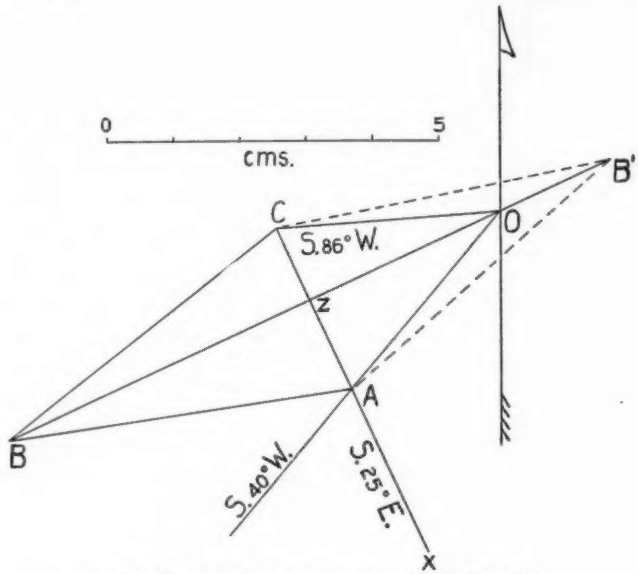


FIG. 4.—Construction to solve the problem of two tilts.

Given: a set of dipping beds overlying with *angular* unconformity a lower set of dipping beds; to find the dip of the lower beds before they were subjected to the tilting indicated by the upper series (assuming the latter were deposited horizontally). Let the upper set dip 30° to S. 25° E. and represent the lower beds which dip 35° to S. 40° W. by OA in Figure 4, where the distance OA is the tangent of 35° drawn to any convenient scale (in Figure 4 the "unit" is taken as 5 cms.; thus $OA = 5$ cms. $\times$ tan $35° = 3.5$ cms.). Through A draw a line Ax running S. 25° E. and extend it both ways. From O drop the perpendicular Oz to Ax and extend it to B or B' so that Bz or $B'z$ is the unit distance on the scale chosen (5 cms. in Figure 4). Lay off the

[26] John L. Rich, *op. cit.*

angle ABC or $AB'C$ equal to 30°, the inclination of the upper set of beds. Then the answer is obtained from the vector OC; namely, S. 86° W. and 34° 13′ (OC = 3.4 cms. = 5 cms. × tan 34° 13′).[27] There must be many areas which have suffered two or more periods of folding separated by erosion intervals about which sufficient data are now available to permit application of this type of graphical analysis. Of course where enough is known of two superimposed structures to permit drawing structure contours on both of them, much more satisfactory analysis can be made by means of convergence methods.

A rapid approximate solution of the problem of two tilts, which also serves as a check on the graphical method, may be accomplished with the Fedorow universal stage mounted on the microscope stage. For convenience in operation the microscope tube is removed, the microscope stage is kept horizontal, and the hemispheres are removed from the U-stage. Designating the axes A of the U-stage as is done by Berek,[28] with $A1$ the inner "vertical" axis and $A5$ that of the microscope stage itself, the check on the problem of the preceding paragraph may be obtained as follows. With $A2$ in what is taken as a north-south direction and $A4$ in an east-west position, note the reading on the vernier of the microscope stage. Revolve the microscope stage 25° counterclockwise around $A5$. This throws $A4$ in a direction at right angles to S. 25° E. Now revolve the table of the U-stage 21° clockwise around $A3$. This places $A2$ in a direction normal to S. 86° W. Rotate about $A2$ by 34° 13′ so that the inner glass plate may be taken as representing a bed dipping S. 86° W. at 34° 13′. Next rotate about $A4$ by 30° as if tilting the whole inner stage to the S. 25° E. The inner glass plate now represents a bed dipping 35° to S. 40° W., as is easily seen with a clinometer and protractor.

Studies of joints in folded but not strongly metamorphosed rocks, tilting them back to positions which if in existence they occupied before the folding, might lead to interesting deductions in certain cases. This idea is at least 100 years old.[29] Harker's later article[30] covers problems of this type (dealing with steeply dipping veins) in which cotangents must be used in place of tangents. The use of

[27] The solution of this problem is simpler if the gnomonic protractor is used as this obviates the necessity of locating B or B' since point C is obtained direct on line Az extended by making zC = 5 cms. × tan (30° − y) where tan $y = zA/5$. See A. Harker, "The Use of the Protractor in Field Geology," *Sci. Proc. Royal Dublin Soc.*, Vol. 8, Pt. I (1893), p. 15.

[28] See footnote 5, p. 550, *Amer. Mineral.*, Vol. 16 (1931).

[29] John Phillips, *Manual of Geology* (1855), p. 643.

[30] A. Harker, "The Use of the Protractor in Field Geology," *Sci. Proc. Roy. Dublin Soc.*, Vol. 8, Pt. 1 (1893), pp. 12–20.

cotangents for larger angles of dip was also emphasized by Oldham[31] who advocated the use of a circular protractor graduated in degrees with a series of concentric circles representing tangent and cotangent values. Problems can be solved easily on this graticule by using two rectangular sheets of paper or "a piece of tracing paper with two straight lines crossing each other at right angles,"[32] quite the same as the cross described by Woolnough[33] more than 50 years later.

[31] R. D. Oldham, "Note on a Graphic Table of Dips," *Geological Magazine*, Vol. 1 (3), 1884, pp. 412–15.

[32] *Ibid.*, p. 415.

[33] W. G. Woolnough, "Simplification of the John L. Rich Dip Construction," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 6 (June, 1935), p. 906.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 21, NO. 3 (MARCH, 1937), PP. 352-359

REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library and available to members and associates.

Festschrift zum 60. Geburtstag von Hans Stille (Hans Stille 60th Anniversary Volume). By many authors. Ferdinand Enke, Stuttgart (1936). 437 pp., 28 plates, many text figures. RM. 20.

The publication of a Festschrift to commemorate important events in the lives of favorite professors is more common in Germany than with us. On such occasions it is customary for the former students of the man who is to be honored to contribute papers that are supposed to owe something to his influence and perhaps to illustrate the breadth of his interests. In most cases the unity of the collection is likely not to be pronounced, and, in many cases, probably the man honored is the only man in the world who might hope to read all the papers in the collection with interest and understanding.

On the 8th of October, 1936, Hans Stille, professor in the University of Berlin and distinguished member of our Association, celebrated his 60th birthday; and on that day his "grateful students," to the number of 54, presented him with a Festschrift containing 26 articles, divided into 8 groups. Only 5 articles are found in the last 4 groups, which deal with the Arctic regions, salt geology, hydrology, and oceanography. The other 21 articles deal with the first four groups: 11 with problems of tectonics in Germany (in Variscan and Saxon-type provinces); 6 with recent earth movements and geomorphology; and 4 with problems relating to Mediterranean lands.

In the first article Walter Schriel discusses the correlation, facies changes, and paleogeography of the Lower Devonian strata of one of the classic Devonian areas, southern Sauerland, in the eastern part of the Rheinisches Schiefergebirge. In the second, Fritz Dahlgrün describes the facies relations in the Silurian and Devonian of the Kellerwald, "that eastern prolongation of the Rheinisches Schiefergebirge." Present structure of the area is shown in one sketch map, Devonian facies in two others. The Silurian is shown to be much less well represented in the region than earlier workers had supposed. In the next article, Friedrich Kühne discusses the facies of the Carboniferous in western Sauerland, also in the Rheinisches Schiefergebirge; the district selected for study is distinguished for the complexity of its facies relations, which are worked out and clearly illustrated, so far as the Carboniferous is concerned, in a sketch map. In the fourth article Kurt Fiege describes and interprets two types of sedimentary cycles in the Culm of the Harz Mountains and furnishes a paleogeographic interpretation for them. His sections and discussion will be of interest to American students of cyclothems.

Walter Emil Petrascheck discusses sedimentation, vulcanism, and copper content of the Rotliegend (Lower Permian) of Middle Silesia, southwest of Breslau near the Riesengebirge. He gives many interesting paleogeographic data, some of them on sketch maps. Hubert Kleinsorge discusses the red rocks of Schleswig-Holstein, with particular reference to their heavy mineral content and its stratigraphic usefulness. Fritz-Erdmann Klingner reports on the tectonics of the Korbach embayment, and its paleogeographic development during the Zechstein (Upper Permian). The region is in the eastern part of

the Rheinisches Schiefergebirge. Eckart Schroeder discusses the Saxon-type structure of the Saar district and its relations to Variscan trend lines in neighboring regions. Gerhard Richter contributes a well-rounded account of the conditions of sedimentation during the Lower Keuper (Upper Triassic) in the district between the Harz and Thuringian forests. Hermann Schmidt discusses the stratigraphic significance of floras from the *Knollensteine* or Tertiary "quartzites" of a region a few miles southwest of Göttingen. The floras are judged to be mainly Oligocene, instead of Miocene as has been generally supposed. Hans Gallwitz furnishes a discussion of the tectonic and physiographic evolution of the valley of the Elbe near Dresden.

Gundlach and Teichmüller contribute a discussion of post-Miocene warping in the North-Alpine marginal deep, of which the Munich basin constitutes the central part. Hans Rudolf von Gaertner discusses the physiography of the east slope of the Fichtelgebirge. Georg Selzer furnishes an account of the stratigraphy of the loess of western Eichsfeld and the valley of the upper Leine, south of Göttingen. He recognizes four periods of loess deposition and explains how they fit into the glacial history of central Germany. Herbert-Lothar Heck discusses the Pleistocene tectonics of the region about the western margin of the Baltic Sea.

In the next article, the only one dealing with a district in North America, Hans Ashauer contributes a summary of the data more recently published by Reed and Hollister as "Structural Evolution of California," and discusses some of the problems of most interest to Stille and his school of geologists. Ashauer's maps and sections are interesting and well drawn, and none of them has been published elsewhere.

Peter Misch contributes an article on a folded sandstone with curious textural features, found in the Indus Valley in the Northwestern Himalayan region. Its age is probably Upper Pliocene or Lower Pleistocene. The article closes with a discussion of recent folding movements of this general area. Herbert Karrenberg furnishes a biostratigraphic study of the Lower Devonian of the Western Pyrenees. The fossils are illustrated on two plates.

Hans Wilhelm Quitzow discusses folding and vulcanism in the Paleozoic "basement rocks" of Corsica, and Andreas Pilger contributes a short discussion of the tectonics of the basement rocks of Provence. Johann Trikkalinos describes the stratigraphy and structure of Attica, with particular reference to the age of the basement rocks. He finds that they belong to several periods—pre-Devonian, late Paleozoic, and Mesozoic; and he points out that his results remove the basis for certain ideas that have been held about nappe structure in Attica.

Hans Frebold contributes a 30-page account of the Upper Paleozoic and Lower Triassic of Spitzbergen. His work is based largely on a paleontological study of collections made by several Norwegian exploring expeditions. As in the case of most of the other papers, there is a good bibliography. Franz Lotze discusses in another 30-page article the relations between the paleogeography and tectonics of salt deposits, a subject to which Professor Stille has contributed at different times. Hans-Joachim Martini discusses the occurrence and origin of the salts of Bad Sulza in the Jena district.

Gerhard Keller gives an account of his hydrologic investigations in the Ruhr valley at Essen. Wolfgang Schott discusses recent deep-sea sediments in their dependence on ocean water. He gives examples to show how the char-

acter of the deposits may reflect either the conditions of the surface waters or of the bottom waters, and points out the significance of his data in the interpretation of ancient deep-sea sediments.

In spite of the variety of authors and of subjects, a little consideration shows that most of these papers deal with that phase of geology to which Stille has devoted his life; that is, to the relation between paleogeography and tectonics, the subject that the reviewer has tried to describe by the term "structural evolution." It is thus easy to suppose that the sponsors of this Festschrift reached their immediate aim, which was to furnish a memorable sixtieth birthday for Professor Stille; and it is also easy to believe that they have reached their secondary aim, which was, presumably, to produce an interesting and instructive geological volume for the perusal of their fellow-geologists in Germany and elsewhere. Oil geologists can hardly fail to be impressed by the close relation that exists between Stille's field of interest and that in which much of their own work is being done.

R. D. REED

LOS ANGELES, CALIFORNIA
February 5, 1937

Naphthen- und Methanöle Ihre Geologische Verbreitung und Entstehung (Naphthenic and Paraffinic Oils, Their Geologic Distribution and Origin). By HANS HLAUSCHEK. Vol. 11 in O. Stutzer's series: *Schriften aus dem Gebiete der Brennstoff-Geologie.* Press of Ferdinand Enke, Stuttgart, Germany (1937). 147 pp., 14 figs. 15 RM (less 25 per cent for sales to most countries outside Germany). In German.

The book is built around the study of extensive series of analyses of Polish and Roumanian crude oil, but extends to a brief survey of the relative conditions of occurrence of naphthenic- and paraffine-base crudes throughout the world. The findings of fact are: (1) character of the oil and age of the reservoir rock: paraffinic oils are the predominant oils in Paleozoic rocks and they are the intermediate base oils in rocks of all ages from Silurian (Ordovician-Lower Silurian) to late Tertiary; the naphthenic oils are the predominant oils in Tertiary rocks but are found in rocks as old as Lower Cretaceous; this relation is strikingly true of North America, and true in a general way of the world as a whole; (2) character of the oil and depth of the reservoir rocks: no general relation holds between character of oil and depth but within individual oil areas, most commonly the oil becomes lighter with depth; (3) character of the oil and tectonics: no relation was found between tectonics and the character of the base of the crude oil (no consideration is given to the problem of the character of the oil and carbon ratio-metamorphism); (4) character of the oil and character of the reservoir rock: no relation was found.

Having made an interesting review of the theories of the formation of oil, the author comes to the final conclusion: (a) the theories which postulate that oil may form at low temperature and pressure and, therefore, at moderate as well as great depth have a greater degree of probability than those which depend on the postulate of the formation of oil as paraffinic oil at great depth; (b) the various chemical characteristics of different crude oils seem most probably to have depended, in the main, on differences in the character of the mother material; (c) once an oil is formed its character changes only slightly;

and (d) for the Carpathian oil provinces, in general, the source beds and reservoir beds probably lie in the same or adjacent formations; the postulation of the origin of the Dacic and Meotic oils from a common mother rock seemingly should be given up; the oil in the Dacic (third oldest Pliocene formation) formed in post-Meotic beds (Meotic=oldest Pliocene formation); the Meotic oil in Meotic beds, or—less probably—in Miocene beds; most of the Flysch oil in the Flysch—contrary to the common teaching that the Flysch is barren of oil; and the late Tertiary oil of the Vienna basin in the late Tertiary beds.

This book presents an interesting original study of the Carpathian oils, an interesting review of the occurrence of the paraffinic and naphthenic oils, throughout the world, a clear formulation of the theories of the relative manner of the formation of naphthenic and paraffinic oils, and conclusions with half of which the reviewer agrees and with half of which he disagrees. The book is well written and readable, the thread of thought is easy to follow, and the German is simple. The book is recommended to students of the subject of the origin and evolution of crude oils.

Three mutually dependent conclusions of the author do not seem to the reviewer to be justified: (a) that the present character of a crude depends, in the main, on the character of the assemblage of mother material; (b) that in general after an oil has been formed, its character undergoes no substantial transformation; and (c) that naphthenic crude oils have not transformed into paraffinic oils under the effect of temperature, pressure and time and other factors.

The question of the degree to which the character of crude oil depends on the character of the original source material seems to the reviewer one about which the data are insufficient for final conclusion. Variations in the assemblage of organic mother material of crude oil seemingly must produce some sort of parallel variation in the resultant crude oil. Intuitively, the vast change in the forms of animal and plant life, particularly the latter, from Ordovician to Pliocene seemingly should be parallelled by some change in the character of the crude oil. Accordingly the theory that the Paleozoic assemblages of organic mother material of petroleum were such as to give rise to paraffinic rather than naphthenic crude oil must be held for the present as an important alternative explanation of the practical absence of naphthenic petroleum from Paleozoic rocks. However, in view of the very great lengths of geologic time since the end of the Paleozoic compared with those since the Eocene, the theory that paraffinic base is the asymptotic end point of evolutionary transformation of the base from naphthenic is an equally good alternative explanation of the character of the Paleozoic oils.

The theses that paraffinic oil can not form from naphthenic and that the character of an oil is relatively stable after the oil has once formed seem to the reviewer inconsistent with the fact of the general decrease with depths of the specific gravity (increase of A.P.I. gravity) of the individual 25°C. cuts in the United States Bureau of Mines analyses for Gulf Coast oils of each of the age groups, Miocene, Oligocene, and Jackson Eocene. The special counter plea might be made that in general the depth of sinking increases linearly gulfward and that the apparent variation of character with present depth is the effect of the original shoreward variation in the character of the assemblage of mother material of the crude oil. In a study now in progress, a criterion has been found which seemingly allows the recognition of some crude

oils of common assemblage of source material; decrease of specific gravity of the distillation fractions with depth is shown by these groups and, therefore, leaves no opening for that special plea. The ease with which the character of crude oil is changed in the refinery intuitively suggests to the reviewer the high probability of parallel changes in nature, presumably at very slow rates, but changes which are appreciable on account of the great lengths of geologic time.

DONALD C. BARTON

HOUSTON, TEXAS
January 27, 1937

RECENT PUBLICATIONS

CALIFORNIA

*"Report on Buena Vista Hills, a Portion of the Midway-Sunset Field," by Paul J. Howard. *Summary, California Oil Fields* (State Oil and Gas Supervisor, San Francisco), Vol. 20, No. 4 (April, May, June, 1935), pp. 5–22; 9 pls., 4 tables. Published in 1936.

CHINA

*"Age of Maping Limestone of China," by Amadeus W. Grabau. *Pan-American Geologist* (Des Moines, Iowa), Vol. 67, No. 1 (February, 1937), pp. 31–38.

ENGLAND

*"Some British Trilobites of the Family Calymenidae," by Jack Shirley. *Quart. Jour. Geol. Soc. London* (London), Vol. 92, No. 368 (Part 4, 1936), pp. 384–422; 4 figs., 3 pls. (42 figs.).

*"The Green Ammonite Beds of the Dorset Lias," by William Dickson Lang. *Ibid.*, pp. 423–37; 1 fig., 1 pl.

*"The Ammonites of the Green Ammonite Beds of Dorset," by Leonard Frank Spath. *Ibid.*, pp. 438–55; 2 figs., 1 pl., 1 table.

*"The Gastropoda and Lamellibranchia of the Green Ammonite Beds of Dorset," by Leslie Reginald Cox. *Ibid.*, pp. 456–71; 1 pl.

*"Brachiopoda from the Lower Lias, Green Ammonite Beds, of Dorset," by Helen M. Muir-Wood. *Ibid.*, pp. 472–87; 11 figs.

ESTHONIA

*"Die Erdgasvorkommen Estlands" (Natural Gas Occurrence in Esthonia), by D. W. Bartels. *Petrol. Zeit.* (Wien), Vol. 33, No. 1 (January 6, 1937), pp. 1–7; 2 figs.

GENERAL

"Bedding Plane Faults and Their Economic Importance," by Charles H. Behre, Jr. *Amer. Inst. Min. Met. Eng.* (New York), *Tech. Pub. 767* (January, 1936).

**"Year Book Section," Amer. Inst. Min. Met. Eng. *Min. and Met.* (New York), Section 2 (January, 1937). Officers and directors, standing and special committees, proceedings of meetings, abstracts, list of separates, and consolidated index for the year 1936.

*"Convenient System Developed for Mapping Oil Pools," by T. P. Sanders. *Oil and Gas Jour.* (Tulsa), Vol. 35, No. 34 (January 7, 1937), p. 32; 1 illus.

*"Determining an Oil Field's Possibilities for Secondary Recovery," by Paul D. Torrey. *Petrol. Engineer* (Dallas, Texas), Vol. 8, No. 4 (January, 1937), pp. 65, 66, 68, 71.

*"Fifth Exploratory Phase To Be Used in Finding New Fields," by W. V. Howard. *Oil and Gas Jour.* (Tulsa), Vol. 35, No. 38 (February 4, 1937), pp. 12, 13; 4 illus. First of a series of 4 articles discussing the changes in exploratory work which will be necessary if the industry is to find new reserves adequate to supply a rapidly increasing demand.

*"Caractères généraux des gisements pétrolifères" (General Character of Petroliferous Beds), by M. de Cizancourt. *Annal. Nat. Combust. Liquides* (Paris), Vol. 11, No. 6 (November–December, 1936), pp. 997–1070; 18 figs.

*"Several Improvements Noted in Production Engineering," by Lyndon L. Foley. *Min. and Met.* (New York), Vol. 18, No. 361 (January, 1937), p. 33.

GEOPHYSICS

*"Geophysical Prospecting for Oil," by J. C. Karcher. *Min. and Met.* (New York), Vol. 18, No. 361 (January, 1937), pp. 11–13.

INDIA—INDO-CHINA

*"On the Supposed Cretaceous Cephalopods from the Red Beds of Kalaw and the Age of the Red Beds," by M. R. Sahni. *Records Geol. Survey India* (Calcutta), Vol. 71, Pt. 2 (1936), pp. 166–69; 1 pl.

*"Contributions to the Geology of the Province of Yunnan in Western China. 9. The Brachiopod Beds of Liuwun and Related Formations in the Shan States and Indo-China," by J. Coggin Brown. *Ibid.*, pp. 170–216; 2 pls.

*"On the Geological Age of the Namyau, Liu-wun and Napeng Beds and of Certain Other Formations in Indo-China," by M. R. Sahni. *Ibid.*, 217–30.

MINNESOTA

*"Petrographic Analysis of the Glenwood Beds of Southeastern Minnesota," by George A. Thiel. *Bull. Geol. Soc. America* (New York), Vol. 48, No. 1 (January 1, 1937), pp. 113–22; 5 tables.

NEW MEXICO

*"Structure of the Sandia Mountains," by Charles Keyes. *Pan-American Geologist* (Des Moines, Iowa), Vol. 67, No. 1 (February, 1937), pp. 39–58; 3 figs., 3 pls.

OKLAHOMA

*"Engineering Report on Oklahoma City Field, Oklahoma," by H. B. Hill, E. L. Rawlins, and C. R. Bopp. *U. S. Bur. Mines* (Washington), *Rept. Invest. 3330* (January, 1937). 243 mim. pp., 69 illus. Published through coöperative assistance of State of Oklahoma. Available upon request from Information Division, U. S. Bureau of Mines, Washington, D. C., or the Bureau of Mines Petroleum Experiment Station, Bartlesville, Oklahoma.

PENNSYLVANIA

*"Martinsburg Limestones in Eastern Pennsylvania," by Ralph L. Miller. *Bull. Geol. Soc. America* (New York), Vol. 48, No. 1 (January 1, 1937), pp. 93–112; 2 pls., 3 figs., 2 tables.

RUSSIA

*"New Materials on the Triassic in the Kuznetsk Basin," by J. F. Adler, N. F. Karpov, M. F. Neiburg, and V. I. Yavorsky. *Problems of Soviet Geol.* (Moscow), Vol. 6, No. 10 (1936), pp. 885–92; 2 figs. In Russian. Summary in English.

*"To the Problem of the Triassic in the Kuznetsk Basin," by B. I. Chernyshev. *Ibid.*, pp. 893–94. In Russian.

*"Upper Cretaceous Deposits in Western Siberia," by L. A. Ragozin. *Ibid.*, 895–99; 2 figs. In Russian.

*"Contributions to the Problem of the Stratigraphy of Pleistocene Deposits in the Environs of Moscow," by E. G. Kachughin. *Ibid.*, pp. 900–07; 2 figs., 3 tables. In Russian.

*"A Method for Determining the Strike and Dip of Rocks by Means of Slanting Drill Holes (Part II)," by K. G. Voinovsky-Krigher. *Ibid.*, pp. 908–16; 1 fig., 5 tables. In Russian.

*"Variscian Structure of the Djezkazgan-Atbasar Region," by V. F. Bespalov. *Ibid.*, No. 11 (1936), pp. 923–37; 7 figs. In Russian. Summary in English.

*"Stratigraphy and Tectonics of the Pre-Paleozoic and Paleozoic Formations of the Northern and the Western Slope of the Djungar Alatau," by M. M. Judichev. *Ibid.*, pp. 938–51; 1 fig. In Russian.

*"On the Nature of the Oil-Bearing Limestone Massifs of Ishymbaevo," by A. A. Trofimuk and A. N. Dubrovin. *Ibid.*, pp. 952–77; 7 figs., 2 tables. In Russian. Summary in English.

TEXAS

*"The Van Oil Field, Van Zandt County, Texas," by Ralph Alexander Liddle. *Univ. Texas Bur. Econ. Geol.* (Austin) *Bull. 3601* (January 1, 1936). 82 pp., 27 pls.

ASSOCIATION DIVISION OF PALEONTOLOGY AND MINERALOGY

**Journal of Paleontology* (Forth Worth, Texas), Vol. 11, No. 1 (January, 1937).

"Nautiloid Cephalopods from the Eocene of California," by H. E. Vokes.

"The Gastropod Genus *Harpa* in the Eocene of the Western United States," by H. E. Vokes.

"*Plicatoderbya*, a New Permian Brachiopod Subgenus," by Horace D. Thomas.

"Upper Jurassic and Lower Cretaceous Foraminifera from the Malone Mountains, Trans-Pecos Texas," by Claude C. Albritton, Jr.

"*Malonophyllum*, A New Tetracoral from the Permian of Texas," by Vladimir J. Okulitch and Claude C. Albritton, Jr.

"Cretaceous and Tertiary Crabs from Panama and Colombia," by Mary J. Rathbun.

"A New Genus of Foraminifera from the Miocene of Venezuela and Trinidad," by William S. Hoffmeister and Charles T. Berry.

"Growth States of Mexican Tertiary Caecids," by R. Lee Collins.

"Ammonites of the Genera *Sonneratia* and *Douvilleiceras* from the Cretaceous of Colombia," by Gayle Scott.

"Fossil Hemiptera from the Fox Hills Sandstone (Cretaceous) of Colorado," by Paul W. Oman.

"New Species of Cambrian Trilobites of the Family Conocoryphidae," by Charles E. Resser.

"Elkanah Billings' Lower Cambrian Trilobites and Associated Species," by Charles E. Resser.

"A Diminutive Fauna from the Shakopee Dolomite (Ordovician) at Cannon Falls, Minnesota," by Clinton R. Stauffer.

"Mollusca from the Shakopee Dolomite (Ordovician) at Stillwater, Minnesota," by Clinton R. Stauffer.

"An Aptian Horizon in the Cretaceous of the Lower Mackenzie Valley," by P. S. Warren.

"New Genera of Mesozoic and Cenozoic Corals," by John W. Wells.

CORRECTION

Bartlesville and Burbank Sands, Oklahoma and Kansas

In the February *Bulletin*, in the article, "Physical Characteristics of Bartlesville and Burbank Sands in Northeastern Oklahoma and Southeastern Kansas," by Constance Leatherock, page 247, Figure 1, the word ELDORADO in the upper part of the map should be EUREKA.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 21, NO. 3 (MARCH, 1937), PP. 360-413

THE ASSOCIATION ROUND TABLE

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election, but places the names before the membership at large. If any member has information bearing on the qualification of these nominees, he should send it promptly to the Executive Committee, Box 1852, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

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SEVENTEENTH INTERNATIONAL GEOLOGICAL CONGRESS MOSCOW, JULY 20–29, 1937

The third circular of the seventeenth International Geological Congress has been issued by the organization committee, I. M. Goubkin, chairman, and A. E. Fersman, general secretary, Moscow 17, Bolshaya Ordynka 32. Copies in English may be obtained from A. A. P. G. headquarters, Box 1852, Tulsa, Oklahoma, and from the official travel agents, Intourist, Inc., 545 Fifth Avenue, New York, or Room 1121, 360 North Michigan Avenue, Chicago, or Monadnock Building, 681 Market Street, San Francisco. Membership application forms, attached to the circulars, are to be addressed to the organization committee in Moscow. The membership fee of ten dollars is to be paid to Intourist, Inc. Abstracts of papers to be presented are to be submitted to the organization committee in Moscow by April 1, 1937.

Subjects for discussion at the Congress are: (1) Problem of petroleum and the petroleum resources of the world; (2) Geology of coal fields; (3) Pre-Cambrian and mineral deposits in the regions of its development; (4) Permian system and its stratigraphical position; (5) Correlation of tectonic processes, magmatic formations, and ore deposits; (6) Tectonic and geochemical problems of Asia; (7) Deposits of rare elements; (8) Geophysical methods in geology; (9) History of geological science; (10) Geology of the Arctic and Antarctic regions; and (11) Definition of the absolute age of rocks.

The third circular describes the excursions before and after the Congress proper. The cost of accommodations for 10 days during the Congress in Moscow and Leningrad, from July 20 to 29, inclusive, is $150, first class, and $80, second class.

	Excursion	*Days*	*Rate*
A-1	Northern Excursion	19	$152.00
A-2	Southern Excursion	19	152.00
A-3	Volga Excursion	19	152.00
A-4	Caucasus Excursion	19	152.00
A-5	Permian Excursion	19	152.00
A-6	For members of families	19	152.00
C-1	Petroleum Excursion	40	320.00
C-2	Siberian Excursion	40	320.00
C-3	Nova Zemlia	23	184.00
C-4	Excursion to the Urals	22	176.00
C-5	To places near Moscow	3	25.00
C-6	For members of families	40	320.00

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EARL A. TRAGER

FINANCIAL STATEMENT, 1936

To the EXECUTIVE COMMITTEE,
THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, TULSA, OKLAHOMA.

Dear Sirs:

We have made an examination of the accounting records of THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS for the year ended December 31, 1936, and now submit the following statements:

Exhibit

A Statement of Financial Condition at December 31, 1936
B Income Statement for the year ended December 31, 1936

Schedule

I Investments at December 31, 1936[1]
II Statement of Income from Publications for the year ended December 31, 1936
III Statement of General and Administrative Expenses for the year ended December 31, 1936

In connection with the examination, we examined or tested the accounting records of the Association and other supporting evidence and obtained information and explanations from employees of the Association. We also made a general review of the accounting methods and of the operating and income accounts for the year, but we did not make a detailed audit of the transactions.

Demand Deposits were reconciled to certificates received directly from the depositories. Reserves of $649.97, provided for doubtful Accounts Receivable appear adequate. Inventory of Publications, in the net amount of $18,750.74, represents quantities as shown by the records, stated at appraised values in accordance with resolution adopted by the Executive Committee and represents publications required for anticipated needs. Investments, together with accrued interest at December 31, 1936, are listed in Schedule *I* and were confirmed to us. Accrued Printers' Charges of $1,678.89 represent accrued charges to December 31, 1936, in connection with the printing of:

Gulf Coast Volume	$1,410.04
Structural Evolution of Southern California	268.85
	$1,678.89

An additional amount of approximately $400.00 will be required to complete Structural Evolution of Southern California, but we are informed that further charges for the Gulf Coast volume will not be material.

Results for the year ended December 31, 1936, are summarized from Exhibit *B* as follows:

Net Operating *Loss*			$−*896.05*
Non-Operating Income:			
Income from "Investments"		$2,332.68	
Net *Loss* from Sale of "Investments"		−*7.83*	
Miscellaneous		5.85	2,330.70
Net Income before Extraordinary Items			$1,434.65
Extraordinary Items:			
Cancellation of "Reserve for Decline in Value of Investments"		$1,895.41	
Recovery of Delinquent Dues previously charged off		902.75	
Collections from Reinstated Members		167.85	
Sale of Library		535.25	
		$3,501.26	
Less: Refunds to Members for Unavailable Bulletins	$347.00		
Loss on Disposal of Capital Assets	21.15	368.15	3,133.11
Net Income for the Period			$4,567.76

The "Reserve for Decline in Value of Investments" has been credited to Income as no reserve is required at December 31, 1936.

In our opinion based on such examination, and subject to the foregoing, the accompanying statement of Financial Condition and related Income Statement correctly reflect the financial condition of THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS at December 31, 1936, and the results of its operations for the year ended on that date.

(Signed) ARTHUR YOUNG & CO., *Accountants and Auditors*

TULSA, OKLAHOMA
February 1, 1937

[1] Schedule *I* is not here published.

EXHIBIT A

STATEMENT OF FINANCIAL CONDITION AT DECEMBER 31, 1936

ASSETS	General Fund	Publication Fund	Research Fund	Total
CURRENT ASSETS:				
Demand Deposits:				
The First National Bank and Trust Company, Tulsa, Oklahoma	$11,722.53	$ 3,488.06	$ —	$15,210.59
National Bank of Commerce, Tulsa, Oklahoma	405.62	—	—	405.62
TOTAL CASH IN BANKS	$12,128.15	$ 3,488.06	$ —	$15,616.21
Accounts Receivable:				
Membership Dues (*Less:* Reserve $207.75)	$ 212.75	$ —	$ —	$ 212.75
Advertising (*Less:* Reserve $177.00)	776.50	—	—	776.50
Other Accounts Receivable (*Less:* Reserve $265.22)	808.33	782.31	—	1,590.64
TOTAL ACCOUNTS RECEIVABLE	$ 1,797.58	$ 782.31	$ —	$ 2,579.89
Accrued Interest Receivable (*Less:* Reserve $659.16)	$ 317.50	$ 73.19	$ 24.14	$ 414.83
Inventory of Publications (Cost)	$33,285.36	$6,745.23	—	$40,030.59
Less: Reserve	21,279.85	—	—	21,279.85
Net Value	$12,005.51	$ 6,745.23	$ —	$18,750.74
Special Publications in Process:				
Gulf Coast Volume	$ —	$ 2,339.08	$ —	$ 2,339.08
Structural Evolution of Southern California	—	726.32	—	726.32
	$ —	$ 3,065.40	$ —	$ 3,065.40
TOTAL CURRENT ASSETS	$26,248.74	$14,154.19	$ 24.14	$40,427.07
INVESTMENTS:				
Cost (Market Value $58,920.95)	$41,707.03	$12,635.94	$1,480.16	$55,823.13
FURNITURE AND FIXTURES	$ 3,806.55	$ —	$ —	$ 3,806.55
Less: Reserve for Depreciation	2,676.20	—	—	2,676.20
	$ 1,130.35	$ —	$ —	$ 1,130.35
PREPAID AND DEFERRED CHARGES	$ 102.91	$ —	$ —	$ 102.91
TOTAL ASSETS	$69,189.03	$26,790.13	$1,504.30	$97,483.46

LIABILITIES AND SURPLUS	General Fund	Publication Fund	Research Fund	Total
CURRENT LIABILITIES:				
Accounts Payable	$ 2,911.23	$ —	$ —	$ 2,911.23
Accrued Printers' Charges	—	1,678.89	—	1,678.89
TOTAL CURRENT LIABILITIES	$ 2,911.23	$ 1,678.89	$ —	$ 4,590.12
DEFERRED INCOME:				
Memberships and Subscriptions:				
Active Memberships	$ 3,445.15	$ —	$ —	$ 3,445.15
Associate Memberships	531.00	—	—	531.00
Subscriptions to Bulletin	2,499.14	—	—	2,499.14
Subscriptions to Bound Volume	426.00	—	—	426.00
	$ 6,901.29	$ —	$ —	$ 6,901.29
Other Deferred Income	245.00	716.88	—	961.88
TOTAL DEFERRED INCOME	$ 7,146.29	$ 716.88	$ —	$ 7,863.17
SURPLUS:				
Balance, December 31, 1935	$56,425.14	$22,616.62	$1,420.65	$80,462.41
Net Income for the Year ended December 31, 1936 (Exhibit B)	2,706.37	1,777.74	83.65	4,567.76
Balance, December 31, 1936	$59,131.51	$24,394.36	$1,504.30	$85,030.17
TOTAL LIABILITIES AND SURPLUS	$69,189.03	$26,790.13	$1,504.30	$97,483.46

EXHIBIT B

INCOME STATEMENT FOR THE YEAR ENDED DECEMBER 31, 1936

	Members	Annual Dues	General Fund	General Fund	Publication Fund	Publication Fund	Research Fund	Research Fund	Total	Total
OPERATING INCOME:										
Dues for Current Period:										
Associate Membership:										
Less than Three Years	188	$ 6.00	$ 1,128.00		$ —		$ —		$ 1,128.00	
Three to Six Years	68	8.00	544.00		—		—		544.00	
Over Six Years	137	10.00	1,370.00		—		—		1,370.00	
	393			$ 3,042.00		$ —		$ —		$ 3,042.00
Active Membership	1,841	10.00		18,410.00		—		—		18,410.00
	2,234			$21,452.00		$ —		$ —		$21,452.00
Less: Transferred to "Income from Publications"—										
Associate Membership	393	$ 6.00	$ 2,358.00		$ —		$ —		$ 2,358.00	
Active Membership	1,841	6.00	11,046.00		—		—		11,046.00	
	2,234			13,404.00		—		—		13,404.00
				$ 8,048.00		$ —		$ —		$ 8,048.00
Net Income from Publications (Schedule *II*)				3,061.40		1,052.20		—		4,113.60
Convention Receipts (Net)				112.51		—		—		112.51
				$11,221.91		$1,052.20		$ —		$12,274.11
GENERAL AND ADMINISTRATIVE EXPENSES (Schedule *III*)				13,072.76		97.40		—		13,170.16
NET OPERATING INCOME—*Loss*				$—*1,850.85*		$ 954.80		$ —		$ —*896.05*
NON-OPERATING INCOME:										
Income from "Investments"			$ 1,749.67		$519.36		$63.65		$2,332.68	
Net Profit—*Loss* from Sale of "Investments"			—*54.61*		46.78		—		—*7.83*	
Miscellaneous			5.85		—		—		5.85	
				1,700.91		566.14		63.65		2,330.70
NET INCOME—*Loss* BEFORE EXTRAORDINARY ITEMS				$ —*149.94*		$1,520.94		$63.65		$ 1,434.65
EXTRAORDINARY ITEMS:										
Cancellation of "Reserve for Decline in Value of Investments"			$ 1,618.61		$256.80		$20.00		$ 1,895.41	
Recovery of Delinquent Dues previously charged off			902.75		—		—		902.75	
Collections from Reinstated Members			167.85		—		—		167.85	
Sale of Library			535.25		—		—		535.25	
			$ 3,224.46		$256.80		$20.00		$ 3,501.26	
Less: Refunds to Members for Unavailable Bulletins		$347.00								
Loss on Disposal of Capital Assets		21.15	368.15		—		—		368.15	
				2,856.31		256.80		20.00		3,133.11
NET INCOME FOR THE PERIOD				$ 2,706.37		$1,777.74		$83.65		$ 4,567.76

SCHEDULE II

STATEMENT OF INCOME FROM PUBLICATIONS FOR THE YEAR ENDED DECEMBER 31, 1936

	General Fund		*Publication Fund*		*Total*	
OPERATING INCOME:						
Dues Transferred		$13,404.00		$ —		$13,404.00
Bulletin Subscriptions		4,072.64		—		4,072.64
Advertising		5,994.34		—		5,994.34
Sale of Bound Volumes and Special Publications:						
Bound Volumes	$ 2,449.84		$ —		$ 2,449.84	
Back Numbers	1,097.87		—		1,097.87	
Structure Volume *I*	—		621.53		621.53	
Structure Volume *II*	697.36		—		697.36	
Geology of California	—		578.65		578.65	
Problems of Petroleum Geology	1,200.88		—		1,200.88	
Geology of Natural Gas	—		2,131.65		2,131.65	
Geology of Tampico Region	—		1,633.60		1,633.60	
Other Publications	81.53		—		81.53	
		5,527.48		4,965.43		10,492.91
TOTAL OPERATING INCOME		$28,998.46		$4,965.43		$33,963.89
COSTS AND EXPENSES:						
Proportion of Manager's Salary	$ 2,700.00		$ —		$ 2,700.00	
Editorial Salaries	1,550.60		—		1,550.60	
Salaries applicable to Bulletin Index	2,905.90		—		2,905.90	
Printing Bulletins	11,554.05		—		11,554.05	
Engraving	1,694.44		—		1,694.44	
Printing Separates	261.98		—		261.98	
Stencil Corrections and Mailing	167.47		—		167.47	
Geology of Tampico Region—Printing and Other Costs	—		3,449.11		3,449.11	
Binding Volume *XIX*	362.50		—		362.50	
Binding additional copies—Geology of Natural Gas	—		475.68		475.68	
Copyright Fees	24.00		—		24.00	
Bulletin Mailing and Express	801.89		—		801.89	
Other Publications—Freight, Express and Postage	342.33		335.31		677.64	
Miscellaneous	239.96		68.22		308.18	
	$22,605.12		$4,328.32		$26,933.44	
Add:						
Inventory—Decrease-*Increase*	3,331.94		*−415.09*		2,916.85	
Total Costs and Expenses		25,937.06		3,913.23		29,850.29
NET INCOME FROM PUBLICATIONS FOR THE PERIOD		$ 3,061.40		$1,052.20		$ 4,113.60

SCHEDULE III

STATEMENT OF GENERAL AND ADMINISTRATIVE EXPENSES FOR THE YEAR ENDED DECEMBER 31, 1936

GENERAL FUND:		
Proportion of Manager's Salary		$ 1,783.04
Clerical Salaries		5,459.08
Office Rent		1,120.00
Telephone and Telegraph		342.35
Postage		1,117.32
Office Supplies and Expenses		813.81
Printing and Stationery		321.47
Donations—		
Society of Economic Paleontologists and Mineralogists	$500.00	
National Research Council	250.00	750.00
Audit Expense		300.00
Investment Counsel		200.00
Insurance		163.58
Bad Debts		78.42
Freight and Express		178.76
Miscellaneous		70.86
Depreciation of Furniture and Fixtures		374.07
		$13,072.76
PUBLICATION FUND:		
Bad Debts		97.40
		$13,170.16

FINANCIAL STATEMENT, DIVISION OF PALEONTOLOGY AND MINERALOGY, 1936

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS,
DR. GAYLE SCOTT, SECRETARY-TREASURER

Pursuant to your instructions I have audited the records of the secretary-treasurer of the Society of Economic Paleontologists and Mineralogists for the period January 1, 1936, through December 31, 1936, and herewith submit my report.

In my opinion this statement is true and correct. All checks were supported by voucher and were properly endorsed. All monies are carried in The Fort Worth National Bank.

Stock of journals on hand is protected by $6,000.00 fire insurance, expiring May 29, 1937.

I found the books and records well kept and the information readily available.

FORT WORTH, TEXAS
January 28, 1937

Respectfully submitted,
(Signed) L. A. DUNAGAN

RECEIPTS				
Membership dues		$ 955.96		
Donations from A.A.P.G.		500.00		
Subscriptions, Journal of Paleontology		1,850.89		
Subscriptions, Journal of Sedimentary Petrology		804.22		
Advertising		107.00		
Plates and separates		234.25		
Paleontology dues collected		16.00		
National Academy of Science		100.00		
Interest earned, savings account		42.89		
Transferred from savings account		1,100.00		
Total Income			$5,711.21	
EXPENSE				
Secretarial and Clerical		570.00		
Postage and permits		81.55		
Printing and stationery		68.35		
Fire insurance		19.44		
Refund of dues and subscriptions		9.20		
Miscellaneous		2.39		
Audit		25.00		
Traveling of secretary to Tulsa		25.00		
Binding		5.50		
Bank charges on collections		2.27		
Refund Paleontological Society for dues paid S.E.P.M.		31.00		
Editor's office expense		101.75		
Allotment to Paleontological Society		400.00		
Printing				
Journal of Paleontology				
Dec., 1935	$ 918.65			
Mar., 1936	715.36			
June, 1936	1,030.51			
Sept., 1936	1,135.13	3,799.65		
Journal of Sedimentary Petrology				
Dec., 1935	258.19			
Apr., 1936	331.32			
Aug., 1936	386.29	975.80		
Transfer savings to checking account		1,100.00		
Total Disbursements			$7,216.90	
Net Operating Loss (cash)				$1,505.69
Cash on hand Jan. 1, 1936				4,184.82
Cash on hand Jan. 1, 1937				$2,679.13

ADDITIONAL INCOME AND EXPENSE
(not cash)

INCOME

Accounts Receivable				
Membership dues		$ 81.00		
Sale of Journals		42.80		
Journal of Sedimentary Petrology				
31 subscriptions due	$ 87.00			
Amount due, back numbers	18.40	105.40		
Advertising		430.00		
Plates for authors' separates		27.50		
Total Receivables			$ 686.70	

EXPENSE

Accounts Payable				
Meriden Gravure Co., net		310.69		
Geo. Banta Publishing Co.	72.58			
Geo. Banta Publishing Co.	248.14			
Geo. Banta Publishing Co.	665.10	985.82		
Total Payables			1,296.51	
Loss			$ 609.81	
Add loss shown on cash statement			1,505.69	
Net Operating Loss				$2,115.50

ASSETS

Current Assets		
Cash on hand	$ 2,679.13	
Accounts receivable	686.70	
Total Current Assets	$ 3,365.83	
Deferred Charges		
Inventory of Journals	25,176.00	
Total Assets		$28,541.83

LIABILITIES

Current Liabilities		
Accounts payable	1,296.51	
Capital Liability		
Net worth	27,245.32	
Total Liabilities		$28,541.83

PAST OFFICERS OF THE ASSOCIATION

In	*Elected At*	*President*	*Vice-President*[1]	*Secretary-Treasurer*[2]	*Editor*[3]
1917	Tulsa	J. Elmer Thomas	Alex. Deussen	M. G. Mehl	C. H. Taylor
1918	Oklahoma City	Alex. Deussen	I. C. White[4]	W. E. Wrather	C. H. Taylor
1919	Dallas	I. C. White[4]	Irving Perrine	C. E. Decker	C. H. Taylor
1920	Dallas	W. E. Pratt	Alex. W. McCoy	C. E. Decker	R. C. Moore
1921	Tulsa	G. C. Matson	G. C. Gester	C. E. Decker	R. C. Moore
1922	Oklahoma City	W. E. Wrather	Max W. Ball	C. E. Decker	R. C. Moore
1923	Shreveport	Max W. Ball	F. W. DeWolf	C. E. Decker	R. C. Moore
1924	Houston	J. H. Gardner	E. G. Gaylord	C. E. Decker	R. C. Moore
1925	Wichita	E. L. DeGolyer	R. S. McFarland	C. E. Decker	R. C. Moore
1926	Dallas	Alex. W. McCoy	C. R. McCollom	Fritz L. Aurin	J. L. Rich
1927	Tulsa	G. C. Gester	Luther H. White	David Donoghue	J. L. Rich
1928	San Francisco	R. S. McFarland	J. E. Elliott	David Donoghue	J. L. Rich
1929	Fort Worth	J. Y. Snyder	Fred H. Kay	A. R. Denison	F. H. Lahee
1930	New Orleans	Sidney Powers[5]	Ralph D. Reed	Marvin Lee	F. H. Lahee
1931	San Antonio	L. P. Garrett	L. C. Decius	Frank R. Clark	F. H. Lahee
1932	Oklahoma City	F. H. Lahee	R. J. Riggs	W. B. Heroy	R. D. Reed
1933	Houston	Frank R. Clark	George Sawtelle	W. B. Heroy	L. C. Snider
1934	Dallas	W. B. Heroy	E. B. Hopkins	M. G. Cheney	L. C. Snider
1935	Wichita	A. I. Levorsen	F. A. Morgan	E. C. Moncrief	L. C. Snider
1936	Tulsa	Ralph D. Reed	C. E. Dobbin	Chas. H. Row	L. C. Snider

[1] From March, 1929, to March, 1932, the corresponding office was *first vice-president.*
[2] From March, 1929, to March, 1932, the corresponding office was *second vice-president in charge of finances.*
[3] From March, 1929, to March, 1932, the corresponding office was *third vice-president in charge of editorial work.*
[4] Died, November 25, 1927.
[5] Died, November 5, 1932.

Association headquarters staff, 1937. The figure in parenthesis is the year in which each began to work for the Association. Seated, left to right: Mrs. Clarice B. Strachan (1936), J. P. D. Hull (1926), Miss Daisy W. Heath (1922). Standing, left to right: Misses Gladys Robertson (1930), Anna D. Whalen (1924), Marie Cummings (1929).

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS MEMBERSHIP LIST

MARCH 1, 1937

HONORARY MEMBERS

The executive committee may from time to time elect as honorary members persons who have contributed distinguished service to the cause of petroleum geology. Honorary members shall not be required to pay dues.—*Sec. 6, Article III, of the Constitution.*

LIFE MEMBERS

The executive committee may grant life membership to members who have paid their dues and are otherwise qualified.—*Sec. 2, Article III, of the Constitution.*

On the payment of two hundred dollars ($200.00) any member in good standing shall be declared a life member and thereafter shall not be required to pay annual dues. —*Sec. 2, Article I, of the By-Laws.*

MEMBERS

Any person engaged in the work of petroleum geology or in research pertaining to petroleum geology or technology is eligible to active membership, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, or in sciences fundamental to petroleum geology, and in addition has had the equivalent of three years' experience in petroleum geology or in the application of these other sciences to petroleum geology or to research in petroleum geology or technology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee, and provided further that these requirements shall not be construed to exclude teachers and research workers in recognized institutions whose work is of such character as in the opinion of the executive committee shall qualify them for membership.

Active members alone shall be known as members.—*Sec. 1, Article III, of the Constitution.*

ASSOCIATES

Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, is eligible to associate membership, provided at the time of his application for membership he shall be engaged in geological studies in an institution of collegiate or university standing, or shall be engaged in petroleum geology; and any person who is a graduate of an institution of collegiate standing, in which he has done his major work in sciences fundamental to petroleum geology or petroleum technology, and who has had the equivalent of one year's experience in the application of his science to the study of petroleum geology, shall be eligible to associate membership, provided at the time of his application for membership he shall be engaged in investigations in the broader subject of petroleum geology and technology.

Associate members shall be known as associates.

Associates shall enjoy all the privileges of membership in the Association, save that they shall not hold office, sign applications for membership, or vote; neither shall they have the privilege of advertising their affiliation with the Association in professional cards or professional reports or otherwise.—*Sec. 3, Article III, of the Constitution.*

HONORARY MEMBERS

(**Deceased)

Campbell, Marius R., 735 Fourth Ave., N., St. Petersburg, Fla.
Decker, Charles E., 508 Chautauqua Ave., Norman, Okla.
**Dumble, E. T.
Goodrich, Harold B., 1628 S. Cincinnati, Tulsa, Okla.
Harris, Gilbert D., Dept. of Geology, Cornell University, Ithaca, N. Y.
Hill, Robert T., c/o Dallas News, Dallas, Tex.
Mendenhall, Walter C., U. S. Geological Survey, Washington, D. C.
Orcutt, W. W., Union Oil Company Bldg., Los Angeles, Calif.
Ordoñez, Ezequiel, Abraham Gonzales 79, Mexico City, Mexico
**Salisbury, R. D.
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COMPLETE LIST OF MEMBERS, ASSOCIATES, HONORARY MEMBERS, AND LIFE MEMBERS

Honorary	14
Life	2
Members	1,893
Associates	432
Total	2,341

EXPLANATION OF SYMBOLS

* Honorary member. † Life member. ‖ Associate. Members are not marked. The year refers to the date of election to membership.

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||Williams, G. Allen, 1509 Second Natl. Bank Bldg., Houston, Tex. '27
Williams, George O., 2540 W. Twenty-second St., Oklahoma City, Okla. '27
Williams, Herbert E., 1314 Second Natl. Bank Bldg., Houston, Tex. '26
Williams, J. Stewart, Dept. of Geology, Utah State Agricultural College, Logan, Utah '37
Williams, W. A., Clay-Jones Apartments, Apt. #1802, 1250 Jones St., San Francisco, Calif. '19
Williamson, Thomas F., Victoria Cottage, Pittenweem Fife, Scotland '32
Willis, Cornelius G., 409 A. G. Bartlett Bldg., Los Angeles, Calif. '25
Willis, Robin, 406 W. Sixty-fourth St., Inglewood, Calif. '27
Willis, S. Morse, 500 N. Seventh St., Ponca City, Okla. '24
Williston, Samuel H., 905 Public Service Bldg., Portland, Ore. '24
Wills, Neil H., Box 529, Carlsbad, N. Mexico '34
Willson, Kenneth M., 3435 Johnette, Shreveport, La. '29
Wilshire, L. M., 1704 S. Evanston, Tulsa, Okla. '23
Wilson, Edward B., Sun Oil Co., Tyler, Tex. '22
||Wilson, Homer, M., Box 250, Marathon, Tex. '27
Wilson, John H., Box 187, Golden, Colo. '21
Wilson, Joseph M., 2410 Wichita, Houston, Tex. '22
Wilson, Malcolm E., 928 Kings Highway, Shreveport, La. '20
Wilson, Robert R., 921½ W. Knoll Drive, Los Angeles, Calif. '30
||Wilson, Thomas C., 2446 N. Maple Ave., Zanesville, Ohio '30
Wilson, Walter B., Box 661, Tulsa, Okla. '21
Wimbish, Forrest E., 517 N. Chautauqua, Wichita, Kan. '28
Wines, Donald Bradford, Tide Water Oil Co., Tulsa, Okla. '29
||Winfrey, Donald B., 428 Park Drive, Norman, Okla. '31
Winham, W. P., Box 1200, Bakersfield, Calif. '28
||Winkler, Hans, 104 W. Thirty-second St., Austin, Tex. '31
Winn, W. E., 3240 Daniel St., Dallas, Tex. '31
Winter, Niles B., Box 949, San Angelo, Tex. '24
||Winterer, Edward V., 2620 San Emidio St., Bakersfield, Calif. '27
Winton, Will M., Texas Christian University, Fort Worth, Tex. '20
Wissler, Stanley G., Union Oil Co. of Calif., Box 511, Compton, Calif. '27
||Wofford, H. R., Jr., Standard Oil Co. of Venezuela, Caripito, Venezuela, S. A. '35
Wolf, Albert G., Texas Gulf Sulphur Co., 1009 Second Natl. Bank Bldg., Houston, Tex. '24
||Wolters, Earl M., Humble Oil & Refg. Co., Drawer D, Houston, Tex. '30
||Womack, Brame, 502 Continental Bldg., Dallas, Tex. '34
Wood, F. C., Jr., Oklahoma Geological Survey, Norman, Okla. '30
Wood, Fred E., Standard Oil Co. of Ind., 910 S. Michigan Ave., Chicago, Ill. '24
||Wood, George R., 188 Calle 20 de Febrero, Salta, Provincia de Salta FCCNA, Argentina, S. A. '30
Wood, James T., Jr., 2695 Lombardy Road, San Marino, Calif. '24
||Wood, J. Pendleton, 341 Marion St., Denver, Colo. '27
Wood, Robert H., 430 Beacon Life Bldg., Tulsa, Okla. '20
Wood, Virgil O., 430 Beacon Life Bldg., Tulsa, Okla. '20
Woodford, Alfred O., Pomona College, Claremont, Calif. '24
Woods, E. Hazen, Box 1144, Midland, Tex. '25
||Woods, Percy O., Humphreys Corp., Mt. Belvieu, Tex. '31
||Woods, R. D., 1605 Humble Bldg., Houston, Tex. '35
Woods, Sam H., Sun Oil Co., Box 1348, Tulsa, Okla. '25
Woodward, George E., The Texas Co., Box 2332, Houston, Tex. '29
Woodward, Harold Robinson, Box 86, Wichita, Kan. '25
Woolley, Glen C., 1138 Amidon Ave., Wichita, Kan. '28
Woolnough, W. G., Dept. of Home Affairs, Canberra, F. C. T., Australia '29
Woolsey, E. V., Box 360, Luling, Tex. '20
Wosk, L. David, 507 Commonwealth Bldg., San Diego, Calif. '24
Wrather, W. E., 4300 Overhill Drive, Dallas, Tex. '17

Wright, Andrew C., 112 W. Phillips St., Tyler, Tex. . . . '20
Wright, A. P., 918 McBirney Bldg., Tulsa, Okla. . . . '22
Wright, Fay Linton, 522-B N. Orange St., Glendale, Calif. . . . '27
Wright, Fred S., Box 24, Midland, Tex. . . . '20
Wright, Harry F., 1101 Philtower Bldg., Tulsa, Okla. . . . '19
Wright, Hugh, 1008 Second Natl. Bank Bldg., Houston, Tex. . . . '30
||Wright, Randall, R. D. 1, Box 8, Ventura, Calif. . . . '35
Wyckoff, J. W., Box 212, Mt. Pleasant, Mich. . . . '35
Wylie, James R., Jr., 2711 Grant Bldg., Pittsburgh, Pa. . . . '21
Wyman, Everett A., Drawer 2040, Tulsa, Okla. . . . '24
Wynn, Warren H., Sinclair Prairie Oil Co., Box 5030, Shawnee, Okla. . . . '26
||Wynne, H. C., 117 E. Vinita, Sulphur, Okla. . . . '36

Yager, Charles E., Box 2110, Fort Worth, Tex. . . . '24
||Yates, Harvey E., Second & Dallas St., Artesia, N. Mexico . . . '36
Yeager, Lloyd I., 409 Kaufman Bldg., Wichita, Kan. . . . '30
Yoakam, Coler A., 2405 First Natl. Bank Bldg., Oklahoma City, Okla. . . . '22
Young, Addison, Box 1605, Midland, Tex. . . . '30
||Young, C. T., Box 389, Seguin, Tex. . . . '27
Young, Jackson S., Box 1422, Monroe, La. . . . '28
Young, Umberto, Republic Petr. Co., 811 W. Seventh St., Los Angeles, Calif. . . . '28
Young, Wilber H., 103 W. Main St., Titusville, Pa. . . . '35

Zaba, Joseph, Rio Bravo Oil Co., Houston, Tex. . . . '33
Zavoico, Basil B., Gulf Bldg., Houston, Tex. . . . '25
Ziebold, William O., 1572 Virginia St., Charleston, W. Va. . . . '29
Zimerman, Sam, Carter Oil Co., Box 13, Salem, Ill. . . . '31
Zimmerman, C. C., The Texas Co., Box 2332, Houston, Tex. . . . '31
Zimmerman, James Z., 511 Union Natl. Bank Bldg., Wichita, Kan. . . . '22
Zoller, Lawrence J., Box 2306, Tulsa, Okla. . . . '21
Zorichak, Joseph J., Stanolind Oil & Gas Co., Philcade Bldg., Tulsa, Okla. . . . '24
Zuber, Stanislav, Hotel Boston, Roma, Italy . . . '31
Zuloaga, Guillermo, Sur. 2, No. 4 Alto, Caracas, Venezuela, S. A. . . . '37

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 21, NO. 3 (MARCH, 1937), PP. 414-420.

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

At the meeting of the Paleontological Society of America, held in Cincinnati, December 29, the following officers were elected: president, Joseph A. Cushman, Sharon, Massachusetts; vice-president, Carey G. Croneis, University of Chicago; secretary, B. F. Howell, Princeton University; treasurer, Carl O. Dunbar, Yale University; and editor, John B. Reeside, the United States Geological Survey.

John F. Kinkel, district geologist in Kansas for the Phillips Petroleum Company, died in Wichita, Kansas, last January from pneumonia.

R. G. Moss is the new division geologist in Kansas for the Phillips Petroleum Company. He succeeds John F. Kinkel.

Clark Millison, in charge of the Oklahoma subsurface division of the Shell Petroleum Corporation, resigned his position, January 1, to form the Exploration Company of America with offices for consulting work in the McBirney Building, Tulsa.

Henry J. Morgan, paleontologist for the Atlantic Refining Company, Shreveport, Louisiana, has been transferred to the southwestern headquarters of that company at Dallas, Texas.

J. M. Armstrong and W. A. Yeager have resigned as district geologist and land man, respectively, for the Sinclair Prairie Oil Company to form a partnership. Their offices are in Midland, Texas.

Noyes B. Livingston, formerly of Fort Worth, Texas, has been transferred to Shreveport, Louisiana, as district geologist of the Skelly Oil Company with offices in the Ardis Building.

Robert E. Hardwicke, attorney, Fort Worth, Texas, has compiled a bibliography of petroleum and natural gas printed by the petroleum engineering and law schools of the University of Texas, at Austin. Copies may be obtained from H. H. Power, of the petroleum engineering department.

F. C. Sealy, production manager of the south Texas division of The Texas Company, with headquarters in Houston, has been transferred to a similar position in California.

L. L. Palmer, San Antonio, Texas, has moved to Wichita, Kansas, to succeed Edward Koester, as division geologist for W. C. McBride, Inc. Koester has joined the Darby Petroleum Corporation as division geologist in Kansas.

Georges Vorbe, geologist for the Stanolind Oil and Gas Company at Midland, Texas, has resigned.

M. T. Halbouty, geologist for Glenn C. McCarthy, Inc., Houston, was the principal speaker at the January meeting of the San Antonio Geological

Society. He discussed the "Geology and Geophysics of the High Island Salt Dome in Galveston County Showing Cap Rock and Salt Overhang."

ED DICKINSON WAPPLER, geologist in the Shreveport, Louisiana, office of the Superior Oil Company, died January 18 following an operation.

L. C. LAMAR presented a paper on the "Geology of the South Burbank Pool," by E. O. MARKHAM and L. C. LAMAR, at the meeting of the Tulsa Geological Society, February 1.

GEORGE FANCHER, of the University of Texas, spoke before the North Texas Geological Society at Wichita Falls, January 29, on the subject of "Water Flooding," particularly in reference to his investigations for the State of Pennsylvania on the Bradford field..

The American Askania Corporation, Houston, Texas, announces a new bulletin, "Prospecting with the Askania Torsion Balance," containing 16 pages, illustrated with 14 figures, including maps of salt domes.

PARKER D. TRASK, of the United States Geological Survey, spoke before the Tulsa Geological Society, January 18, on "Means of Recognizing Source Beds," the most recent research findings.

LLOYD E. WELLS, consulting geologist of Wichita Falls, Texas, died January 24.

E. B. RENAUD spoke before the Rocky Mountain Association of Petroleum Geologists, at Denver, Colorado, February 1, on the subject of "Indian Pictographs of the Western Plains."

The Schlumberger Well Surveying Corporation and the International Geophysics Company announce the pooling of their well-logging patents. As in the past, all work in open holes will be handled by Schlumberger Well Surveying Corporation, and the International Geophysics Company will limit its activities to perfecting its method of logging cased holes. The fact that the alternating current patents belonging to the International Geophysics Company are now the property of the Schlumberger Well Surveying Corporation further strengthens the outstanding position held by the latter company in the field of bore-hole surveying by electrical methods, inasmuch as the alternating current detailed techniques supplement in certain respects the basic patents owned by Schlumberger on the principle of resistivity and porosity surveys.

The Gulf Coast Section of the American Institute of Mining and Metallurgical Engineers elected the following officers for the coming year: chairman, WILLIAM VICTOR VIETTI, senior petroleum engineer of The Texas Company, Houston; vice-chairman, H. D. WILDE, Humble Oil and Refining Company, Houston; secretary-treasurer, ALEXANDER DEUSSEN, consulting engineer and geophysicist. Four directors were elected: H. E. TREICHLER, Texas Gulf Sulphur Company; C. A. WARNER, Houston Oil Company of Texas; F. B. PLUMMER, University of Texas; and HAROLD VANCE, Texas Agricultural and Mechanical College.

C. V. SIDWELL, in charge of field operations for the British American Oil Producing Company for the past 19 months, is organizing the production engineering department of the company and will be its active head.

C. W. TOMLINSON, consulting geologist of Ardmore, spoke before the technical meeting of the Oklahoma City Geological Society, January 11, on "Structure of the Arbuckles."

M. R. VERCESI addressed the Oklahoma City Geological Society on "Regional Geology of Uruguay," at a noon luncheon recently.

FRED B. PLUMMER, of the University of Texas, was the speaker at the meeting of the Houston Geological Society, January 14, discussing the Chittim anticline of Maverick County, Texas.

JOHN I. and P. D. MOORE, consulting geologists, have moved their headquarters from San Angelo to Midland, Texas, where offices have been established in the Petroleum Building.

H. B. STENZEL was the speaker at the meeting of the Houston Geological Society, January 28, discussing the correlation of the Claiborne from northeast to southwest Texas.

H. F. MOSES, of the Carter Oil Company, has moved from Mount Pleasant to Saginaw, Michigan.

H. G. KUGLER, formerly at Point-a-Pierre, Trinidad, is now making his headquarters in Basle, Switzerland.

K. D. WHITE, petroleum geologist, is moving his office from London to Bucharest, Rumania, where he may be addressed, Bulevardul Tache Ionescu, 1.

GEORGE L. KLINGAMAN, of The California Company, has been transferred from Midland to Smith-Young Tower, San Antonio, Texas.

GEORGE M. FOWLER and CHARLES H. BEHRE, JR., are the authors of "Mining Geology," in *Mining and Metallurgy*, Vol. 18, No. 361 (January, 1937), pp. 11-13.

A. E. OLDHAM, formerly chief geologist of the Arkansas-Louisiana Gas Company, Shreveport, Louisiana, has resigned to accept a similar position with the American Liberty Oil Company, Dallas, Texas.

RUSSELL S. MCFARLAND, vice-president of the Seaboard Oil Corporation, Dallas, Texas, has been elected president of the Dallas Petroleum Club.

EARL B. NOBLE, assistant manager of exploration of the Union Oil Company, has been appointed chief geologist and HAROLD HOOTS, assistant chief geologist, with offices in Los Angeles, California.

M. G. CHENEY, president of the Anzac Oil Company, addressed the Shreveport Geological Society at its January meeting, the subject being "The Migration of Oil."

J. LEONARD DAVIDSON presented motion pictures of torsion-balance ex-

ploration in Borneo and Sumatra at the meeting of the Houston Geological Society, February 4.

E. G. GAYLORD, of the Standard Oil Company of California, San Francisco, has been named chairman for 1937 of the American Petroleum Institute's advisory committee on fundamental research on occurrence and recovery of petroleum. Members of the committee are: C. A. YOUNG, American Petroleum Institute, Dallas, secretary; F. R. CLARK, The Ohio Oil Company, Tulsa; K. C. HEALD, Gulf Oil Corporation, Pittsburgh; W. B. HEROY, Consolidated Oil Corporation, New York; F. H. LAHEE, Sun Oil Company, Dallas; A. W. McCOY, Marland Oil Company, Ponca City; C. V. MILLIKAN, Amerada Petroleum Corporation, Tulsa; T. V. MOORE, Humble Oil and Refining Company, Houston; K. B. NOWELS, Forest Production Company, Nowata, Oklahoma; R. D. REED, The Texas Company, Los Angeles; R. B. ROARK, Shell Petroleum Corporation, Tulsa; A. C. RUBEL, Union Oil Company of California, Los Angeles; W. C. SHUTTS, Standard Oil Development Company, New York; F. E. WOOD, Standard Oil Company (Indiana), Chicago; and H. D. WILDE, JR., Humble Oil and Refining Company, Houston, as alternate to T. V. MOORE.

J. P. McCULLOCH, formerly consultant to Raffineries de Petrole de la Girdonde, an affiliate of The Texas Company in France, recently left Montreaux, Switzerland, to take up executive work with the California Standard Oil Company, Ltd., London.

T. L. ALLEN, of the Petty Geophysical Engineering Company, San Antonio, presented a paper on "Theory of Reflection Seismograph and Its Application" to the San Antonio Geological Society, February 5.

J. E. BRANTLY is the author of "Needed Improvements in Rotary-Drilling Equipment," published in *Mining and Metallurgy*, Vol. 18, No. 362 (February, 1937), pp. 98–103; 3 illus.

H. FOSTER BAIN has left for Manila where he will be adviser to the Philippine Government on mining matters for about 6 months.

GAIL F. MOULTON, formerly with the Electric Bond and Share Company, New York City, is now with RALPH E. DAVIS, at 150 Broadway.

C. N. GOULD, of the National Park Service, spoke on the Big Bend National Park project at the meeting of the West Texas Geological Society, February 9, in Midland, Texas.

The patent infringement suit of The Texas Company vs. Sun Oil Company pending in the Federal Court, Houston, Texas, has been postponed as it is understood that the suit will be settled out of court. The case involves the Mintrop and McCollum patents pertaining to seismographic methods of locating subterranean oil structures and is of large interest to the oil industry. While the final agreements have not been concluded, it is understood that under the terms of the settlement the members of the primary group of major companies who have borne the burden of the defense are each acquiring a release and license from The Texas Company and that a release and license under the same terms will be offered to the numerous members of the secondary group. Each member of the group involved in the settlement, both pri-

mary and secondary, account for their releases and licenses on the basis of $10,000 per seismographic party, with the understanding that a completely paid-up license for an unlimited number of parties for the personal use of the licensee can be acquired for a total payment of $125,000. It is understood that several of the primary members are acquiring completely paid-up licenses.

JOHN T. LONSDALE, professor in the department of geology at the University of Iowa, represented the Association at the inauguration of CHARLES EDWIN FRILEY as president of the University, at Ames, October 7, 1936.

G. D. THOMAS, recently assistant to vice-president W. VAN HOLST PELLEKAAN of the Shell Petroleum Corporation at St. Louis, Missouri, has been transferred to the Shreveport office as district geologist. HUGO R. KAMB is assistant district geologist.

HANS STILLE, of the Geological Institute, University of Berlin, has been elected an honorary member of the Association.

F. B. PLUMMER, of the department of petroleum engineering, at the University of Texas, spoke on "Oil Reservoirs" before the North Texas Geological Society, at Wichita Falls, Texas, February 26.

ROSS HEATON spoke on "Stratigraphy versus Structure in the Rocky Mountain Region" before the Rocky Mountain Association of Petroleum Geologists, at Denver, Colorado, February 15, 1937.

WILLARD BERRY, of the Duke University department of geology, spoke before the local chapter of Sigma Gamma Epsilon at the University of North Carolina, at Chapel Hill, on January 14, 1937. The topic of discussion was "Pollens and Spores of the Paleozoic Coals."

HENRY A LEY, geologist for the Rio Oil Corporation and R. D. Goodrich, at Fort Worth, Texas, since 1932, has resigned.

The Southwestern Geological Society, the Bureau of Economic Geology, and the department of geology of the University of Texas were hosts to the geologists of Texas and adjacent states on Saturday, February 13, 1937. At a preliminary meeting at the Stephen F. Austin Hotel, Friday evening, the leaders of the three field trips briefly outlined the area to be covered. The trips offered were as follows: one to the Central Mineral region under the leadership of H. B. STENZEL; one to the Cretaceous in the vicinity of Austin under the direction of F. L. WHITNEY; and one to the Lower Tertiary east of Austin led by R. H. CUYLER. Approximately 140 geologists attended the various field trips. Following the trips, dinner was served at the University Commons. At the dinner, president BENEDICT of the University of Texas, spoke briefly of his student days at the University of Texas under R. T. HILL, first professor of geology, and F. W. SIMONDS, Hill's successor. Both HILL and SIMONDS were guests at the dinner. At the close of president Benedict's talk, portraits of Hill and Simonds were presented to the department of geology to be hung in the Seminar Room of the Geology Building. Following the presentation of the portraits, PARKER D. TRASK, a graduate of the University of Texas, spoke on "Source Beds of Petroleum." Following his address the visiting geologists were conducted through the Geology Building and entertained at an informal reception by the faculty and students.

FRANK BUNDY, former secretary-treasurer of the North Texas Geological Society has resigned from the Humble Oil and Gas Company and accepted a position with the Barnsdall Oil Company, Rockport, Texas. JOHN T. SANFORD, of the Magnolia Petroleum Company, is the new secretary-treasurer of the society.

F. B. PLUMMER, of the University of Texas, addressed the North Texas Geological Society, February 26, at the Wichita Club, on the subject, "Oil Reservoirs."

F. P. SHEPARD, of the University of Illinois, addressed the Tulsa Geological Society, March 1 on " 'Submarine Canyons Related to Salt Domes' Results of Recent Submarine Surveys of Atlantic, Gulf, and Pacific Coasts."

H. W. OBORNE and W. O. THOMPSON were the speakers at the meeting of the Rocky Mountain Association of Petroleum Geologists, held in Denver, March 1. Their subject was "Paleozoic Stratigraphy and Oil Possibilities of Eastern Colorado."

The New Mexico Geological Society has elected the following officers for the year 1937: president, H. G. WALTER, The Texas Company, Hobbs; vice-president, E. W. KIMBALL, Continental Oil Company, Hobbs; secretary, F. B. CONSELMAN, Gulf Oil Corporation, Hobbs; and treasurer, JAMES R. DAY, Amerada Petroleum Corporation, Monument, New Mexico.

The department of geology and geography of Northwestern University offered its second series of exchange lectures for the academic year, 1936–37, February 23, 24, and 25. This exchange was with the department of geology of the University of Kansas, the series being given by RAYMOND C. MOORE, chairman of that department and State geologist of Kansas, who lectured on "Practical Problems in Stratigraphic Field Work," "Problems of Sedimentation in Late Paleozoic Rocks," and "Problems of Major Classification and Inter-Continental Correlation of Late Paleozoic Rocks." The departmental lectures at the University of Kansas were given by JOHN R. BALL, associate professor of geology and paleontology at Northwestern University, March 15–18, on "Stratigraphic Problems of the Early Paleozoic Rocks in the Mississippi Valley."

The Michigan Geological Society, Mount Pleasant, Michigan, has elected its first officers: president, R. B. NEWCOMBE, geologist of the Associated Petroleum Company; vice-president, R. A. SMITH, State geologist; secretary-treasurer, W. A. CLARK, Michigan Elevation Service; business representative, LYNN K. LEE, Pure Oil Company; program chairman, BEN F. HAKE, Gulf Refining Company; chairman of arrangement committee, W. A. THOMAS, McClanahan Oil Company.

At the spring meeting of the American Petroleum Institute, Mid-Continent district, Division of Production, held February 25–26, 1937, at the Mayo Hotel, Tulsa, the following papers were presented: "Résumé of the Panhandle Gas Problem," by H. M. STALCUP, vice-president, Skelly Oil Company; "Conserving Prosperity in the Petroleum Industry," by JOSEPH E. POGUE, vice-president, Chase National Bank; "Fitts Pool—Geology and Development," by K. R. TEIS and MAURICE TEIS, E. H. Moore, Incorpo-

rated; "Water Flooding in Mid-Continent Area," by LAWRENCE E. SMITH, National Petroleum News; "Portable Rigs for Shallow Drilling," by D. M. AULD, Phillips Petroleum Company; "Modern Well Completion Methods," by A. W. WALKER, Stanolind Oil and Gas Company; "Plugging Back Wells to Exclude Water," by C. P. PARSONS, Halliburton Oil Well Cementing Company; "Public Asphyxiation," by FRANK B. LONG, vice-president, Oklahoma Natural Gas Company; "Potential Methods in Kansas," by T. A. MORGAN, director, Conservation Division, State Corporation Commission of Kansas; and "Truck Mounted Rotary Drilling Rigs," by C. M. COPELAND, Helmerich and Payne, Incorporated.

JOHN CLARK, research assistant in Princeton University, has been appointed instructor in vertebrate paleontology and curator of vertebrate fossils in Texas Technological College at the beginning of the current semester, February 1.

S. A. PACKARD, of Shreveport, Louisiana, has been promoted to head of the geological department of the Arkansas-Louisiana Gas Company and affiliated companies, with headquarters in Shreveport.

CORNELIUS SCHNURR, district geologist for the Mid-Continent Petroleum Corporation in various Texas fields, is now a consulting geologist with offices in Midland, Texas.

The first number of the new *Boletin de Geologia y Mineria* has been issued by the recently established Servicio Tecnico de Mineria y Geologia of the Venezuelan Government. It contains the preliminary notices of the First Venezuelan Geological Congress held February 15–23 at Caracas. Approximately 40 geologists attended the congress from Venezuela and Trinidad. Fifteen papers were presented, followed by a 2-day field trip. The members of the new Geological Commission are GUILLERMO ZULOAGA, SANTIAGO AGUERREVERE, and MANUEL TELLO.

ION POPESCU-VOITESTI now occupies the chair of geology at the University of Bucarest, Roumania.

BERTE HAIGH, assistant geologist in charge of University Lands, gave "A Résumé of Oil Development in West Texas and Southeastern New Mexico during 1936" before the West Texas Geological Society at Midland, Texas, March 9.

A. ROZLOSNIK, chief of the division of geology and mines of the Argentine Government Oil Fields, Buenos Aires, and PEDRO REY, of the same organization, are studying conditions and methods in the oil and gas fields of the United States.

LYNDON L. FOLEY, geologist and engineer with the Ohio Oil Company at Tulsa, resigned his position effective March 15 to enter independent work.

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